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VEHICLE MAINTENANCE AND MANPOWER IN THE USAF

by

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Prepared for B.A. 398 under the Supervision of

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B. H. S., Jr.

The University of Texas at Austin
November 1, 1976

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INTRODUCTION

There are two famous quotations used about military transportation. General Nathan Forrest said in the Civil War that his policy was, "Git thar firstest with the mostest." Certainly the emphasis on logistics has grown, and the deployment time has gone from months to days. Winston Churchill noted the importance of logistics when he observed, "Victory is the bright-colored flower; transportation is the stem without which it could never have blossomed."

If transportation has gained recognition, it has been in the area of mobility. Billions of dollars are spent for cargo aircraft such as the C-130, C-141, and the C-5; contracts with airlines under the Civil Reserve Air Fleet cost millions more. Yet with all of this attention, there is still neglect of transportation in the United States Air Force (USAF). Churchill's adage is still true, but the unglamorous "stem" is not the cargo airplane; it is the lowly vehicle.

In the USAF, the mission has always been "to fly and fight." Neither activity can be done in a vehicle.

Still, the role of vehicles is essential. Many special purpose vehicles directly support the flying mission. For example, snow removal equipment is needed to clear runways, especially at the northern Strategic Air Command bases. Refueling vehicles and cargo loaders have similar direct effects on the missions. Other vehicles have more pedestrian purposes such as forklifts, buses, trucks, and sedans.

This report examines the procurement, management, and maintenance of USAF vehicles. It is based on available data, necessary assumptions, and an objective analysis. The requirement for a given vehicle is determined by the user's justification and approved on a judgment basis. It is replaced using data that is unselective and is not based on full cost. Further, a budget decision is often made on noneconomic criteria. Vehicles must compete with other projects in the Operations and Maintenance category. A subjective decision is made on which items are most important. Frequently vehicles are not purchased in a timely manner. ~~For instance~~, in 1954, no vehicles were purchased. If purchase compromises are subjectively made by the USAF, Congress has shown itself to act even more capriciously. Decisions appear to be influenced by

control over a very small number of sedans used by high ranking executives.

Once in the USAF inventory, vehicles are maintained by the transportation organizations. The basis for manning of these units is called a "vehicle equivalent," a subjectively determined measure of repair difficulty.

While subjectivity is a questionable management tool, it is an excellent identifier of problems. Morale in vehicle maintenance shops is bad because of excessive overtime; the amount of delayed maintenance is sometimes high; mechanics, especially military members who receive no additional pay, often work extensive overtime; and the quality of the maintenance is poor.

Certainly the above observations are subject to criticism. Many units are well manned, and work on an up-to-date, well maintained fleet; but the pervasiveness of the problems suggests systematic faults in total management of USAF vehicles. This system includes Congress, General Services Administration, Headquarters USAF; U.S. Army, Air Force Logistics Command (AFLC), Management Engineering, and base-level supply and transportation units.

The central theme that connects these activities is the effect of maintenance. The present system raises obvious general questions:

A. If vehicles are the same make, does the learning curve improve maintenance, reduce parts inventories, and reduce training time?

B. Does a vehicle with more age or mileage require more maintenance?

C. Does geography or weather affect maintenance?

D. Is operator care better on newer vehicles?

E. Are some makes easier to maintain than others?

The answer to many of the above questions may seem apparent, but intuition is not sufficient. When purchasing new vehicles, a procurement official needs information. A trade-off between initial cost and follow-on operating and maintenance costs requires information if a low, total system cost is to be used as a purchase criteria. Similarly, decisions on when to replace vehicles must consider the manpower effect of retention. The actual level of manning at a given base can be affected by the distribution of types and conditions. If the manning level is inaccurate, morale and level of maintenance are degraded. Current measures of maintenance costs indicate the number of hours worked, but the actual quality of the work, or the work left undone, is not often shown. The result, in the long run, is reduced economic life and eventual increased procurement requirements.

The situation, then, is "you can pay now, or pay later." The research question is to determine the most important operating cost, manpower, in relation to the vehicle fleet. In order for Congress and vehicle management experts to make informed decisions, the impact of changes in the vehicle fleet on maintenance manpower must be known. The premise of this study is that the current manpower standard is insensitive to fleet changes, and has caused distortions in procurement, retention, manning, and the actual capability of the fleet to perform its intended mission.

The current manpower standard is a weighted factor based on a subjective evaluation of the degree of difficulty in maintaining a vehicle of that type. For example, a light sedan is coded "B104" and has a "vehicle equivalent" of 1. Whether it is a Chevrolet or Ford, new or ten years old, lightly used or driven continuously, does not change the factor.

Using regression analysis, several condition factors were used to determine if they were related to manpower use.

The research plan was designed to use existing data. The vehicle condition data were readily available

through the Vehicle Integrated Management System (VIMS). Unlike a normal management engineering survey, another method had to be found for a measure of manpower. Instead of a subjective--although expert--work sample, the manpower measurement was the time recorded on work orders by vehicle in 1975. Of course, to be accurate, additional time for cleanup, breaks, supervision, and training would have to be added to this direct measurement.

The intent was to find a method that would require little manpower or computer programming effort. At the same time, the method would have to show the effects of fleet composition change. The primary drawback of the current standard is that it is so inflexible. It is possible that the present standards were accurate when they were first developed, but time and procurement actions have changed the fleet, and changed the maintenance requirement. Any new standard must be capable of periodic change. For example, if the fleet were composed entirely of three-year-old pickup trucks, there would be one standard. If few or no new trucks were purchased for two years, the maintenance requirement would be different for a fleet of five-year-old vehicles. With an easily updated manpower standard, the vehicle managers would tell in advance the effects of procurement or retention decisions.

With the cooperation of Systems Command and Training Command, all vehicles at their bases were available for the sample. While numerically sufficient, the unique situations in adverse geographical or climatic conditions could not be evaluated. Neither could the effects of a foreign national workforce at overseas locations be determined.

It is clear that the current standard, vehicle equivalents, is a poor predictor of manpower requirements. Indeed, a precondition for success of this standard is a fleet with unchanging composition and equal distribution. For example, if a geographical area is given new vehicles, the maintenance requirement is reduced, while the number of vehicle equivalents remains the same.

It would be gratifying to report a new standard that would accurately predict manpower requirements. Despite various variables, and combinations thereof, and the testing of many curvilinear models, there was no extremely well-fitting factor found. The best variable tested was the amount of hours or miles driven in the preceding year. While within USAF statistical suitability limits, it must be reluctantly concluded that the maintenance manpower requirements depend on a wide variety of factors, and no

single determinant, or combination of determinants, can predict needs for every vehicle type, in any condition, in any location.

As an aggregate measure, though, this tailored-to-type system is more useful, and easier to update than the old system. It also has the advantage of being much more accurate than the current standard.

The advantages and limitations of this approach will be explored in detail as vehicle management, manpower determination, and procurement are integrated in this report.

CHAPTER II

USAF VEHICLE MANAGEMENT

Vehicle management in the USAF is a bewildering array of conflicting organizations and functional areas within organizations. Before describing the relationships of the current procedures, a brief history of vehicle management will be useful in understanding the development of system as it has finally evolved.

When the USAF separated from the Army, following World War II, there was a change in emphasis in vehicle policy. The vehicle was not a direct, integral part of a weapon system. From 1947-1950, the prime management agency was Headquarters, Air Material Command (AMC), whose prime function was to dispose of excesses. At the newly formed Hq USAF, vehicle maintenance was subordinated to aircraft maintenance.

Later, management responsibilities were decentralized to the Warner Robbins Air Material Area (WRAMA). The Korean War intervened, and a comprehensive vehicle

policy was not produced.[1] Still, this was an effort to look at vehicles as a system rather than just another piece of equipment, like a typewriter or desk.

In 1954, management was further decentralized, and the 2709th Vehicle Control Group was established, with final authority on all vehicle actions. Inspections and detailed inventories were made on a worldwide basis. New information and reporting systems were developed, with authorizations, assets, and requirements being computed with a more credible methodology. In fact, the creation of credibility was one of the prime reasons for the increased emphasis on vehicles. In 1954, Congress had criticized the program, and refused to authorize funding for any vehicles.[2]

Despite the success of this intensive management, an economy action caused the 2709th Gp to be disbanded in 1964, with the functions again being placed with WRAMA, although this time a Vehicle Inventory Management

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[1]Keith E. Burres and Michael H. Smith, "An Analysis of the Need for Specialized Management of the Air Force Special Purpose Vehicle Fleet" (Master's thesis, Air Force Institute of Technology, 1973), p. 42.

[2]Ibid.

Division was created. In 1972, this entity was consolidated with the Aircraft Accessories Division. Although special programs or congressional interest sparks activity, the net result of continued subordination and consolidation has been a deemphasis on management. The Vehicle Integrated Management System has enabled the collection of vast amounts of raw data, but there is no central action agency in the USAF to manage the fleet.[3]

Concurrent with vehicle management, the responsibility for the program has been varied at headquarters levels. The Directorate of Supply is in charge of asset control and reporting. This is a function of matching requirements with assets. Maintenance of vehicles was the responsibility of the Aircraft Maintenance Directorate until 1969, and has been in the Directorate of Transportation ever since. The classic argument over control is evident in the continuing debate over where vehicle maintenance belongs in the organization. Aircraft maintenance tends to be a functional argument, saying the skills are similar, such as the methodology of periodic inspections, quality control, scheduling, and training. It is true

[3]Ibid., p. 45.

that some vehicles, such as start carts or aircraft towing tractors, are treated as support equipment, and repaired by aircraft maintenance squadrons. The opposing argument is that transportation is a system. Coordination between operations and scheduling can produce efficiencies. Control over licensing can affect vehicle abuse or misuse, which can affect maintenance. Influence over dispatch, supplemental renting, and rotation also has maintenance consequences.

The timing and amount of vehicle procurement can produce maintenance effects through keeping vehicles too long, or keeping numbers so small that vehicles are worn out quickly. Congress has the major influence, since they have ultimate funding control. In the actual buying, though, the responsibility for making purchases is fragmented. Formerly, USAF vehicle purchases were made through the Army Tank Automotive Center. This had many problems, such as different reporting systems and limited buys. The result was that the USAF usually was the last to obtain a buy; flexibility was lost on making changes to the original specifications, or destinations; the transportation cost was somewhat higher than General Services

Administration's (GSA), and interservice rivalry was suspected.[4] The system did have the advantage that the Army had the capability to extensively test vehicles.

The present system has WRAMA (now called Warner Robbins Air Logistics Center--WRALC) buying a few specialized types of vehicles such as:

1. Fire trucks
2. Runway sweepers
3. Aircraft loaders
4. Refuelers.[5]

The Defense Construction Supply Center buys snow-removal equipment. The Army continues to buy other vehicles with a gross weight over 8,000 lbs., such as bulldozers or cranes. This fragmentation has serious consequences. The Army delays purchase until it can make an economical buy. Since these types of vehicles already have a long lead time, a base has a great deal of uncertainty whether it should continue waiting, or make a time-consuming, expensive repair job.[6]

---

[4]Fletcher B. Porter, "The USAF Vehicle Procurement Program" (Master's thesis, Air Force Institute of Technology, 1964), p. 13.

[5]Burres, et al., p. 59.

[6]Ibid., p. 63.

The remainder of the vehicles are now bought by the General Services Agency (GSA). This gives benefits, especially in responsiveness and lower costs. It still has a major drawback in that GSA's policy of purchasing on the basis of lowest cost considers only the initial price.

With this brief historical background as a framework, the present system will be considered in detail. A description of the vehicle fleet is necessary. A vehicle can be a military design or commercial design, although many manufacturers and parts are the same. Vehicles can also be classified as to construction, materials handling, special purpose, and general purpose. Exhibit A gives a breakout of the composition of the fleet. Table 1 shows a functional breakout of the fleet since 1956. It depicts a steady decline in numbers, corresponding with a reduction in personnel strength over this period from 909,958 to 584,071.[7] This change has two effects. First, the composition changes over time. The percentage of the fleet in the harder-to-maintain special purpose category has increased. Second, there is a tendency to let excesses

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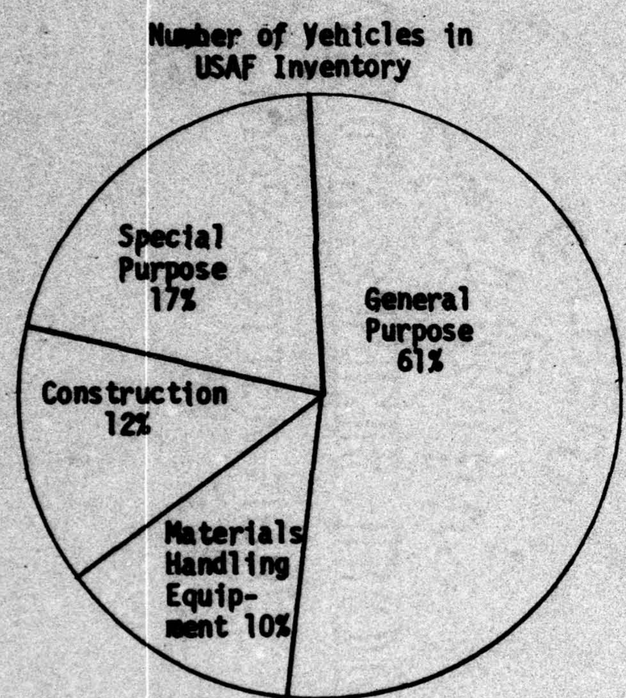
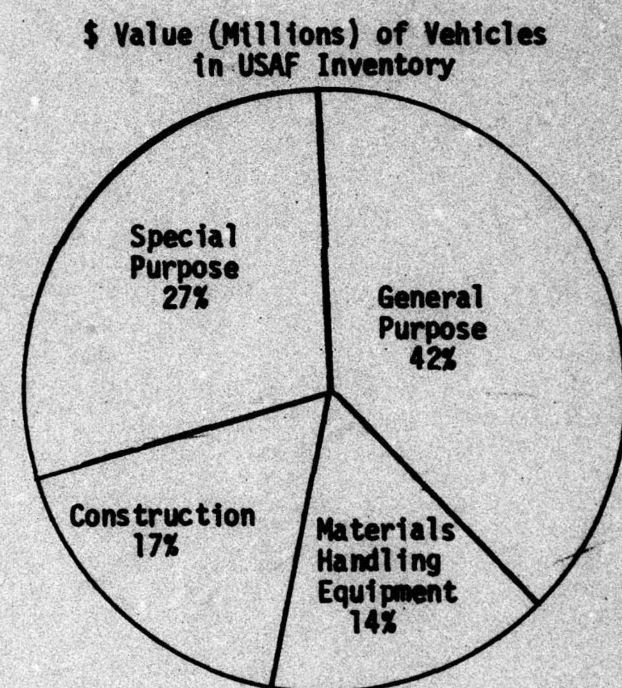
[7]"An Air Force Almanac," Air Force, May 1976, p. 132.

EXHIBIT A





COMPARISON OF USAF VEHICLE INVENTORY AND DOLLAR VALUE BY VEHICLE CATEGORY

SOURCE: Larry L. King, "USAF General Purpose Vehicle Buy Program" (Professional Study, Air War College, 1976/, p. 31.

TABLE 1

DEPARTMENT OF THE AIR FORCE VEHICULAR EQUIPMENT INVENTORIES

Year	Vehicle Category						
	Passenger Carrying	Cargo and Utility	Special Purpose	Fire Fighting	Materials Handling	Base Maintenance	Totals
1956	16,224	112,070	39,215	3,471	24,846	14,103	209,929
1957	16,731	93,825	37,059	3,423	23,128	13,376	187,542
1958	14,488	68,273	31,140	3,316	18,280	10,899	146,396
1959	14,910	67,839	31,449	2,754	16,718	9,885	143,555
1960	14,229	58,665	29,102	2,503	15,932	9,784	130,215
1961	16,059	63,535	28,239	2,496	14,393	9,207	133,929
1962	14,035	63,921	27,708	1,633	13,205	8,575	129,347
1963	15,456	67,590	23,175	2,357	12,595	9,317	130,490
1964	14,860	61,590	22,382	2,678	12,729	8,817	123,056
1965	14,713	64,795	21,822	2,978	14,957	8,102	127,367
1966	15,239	70,013	23,895	2,678	16,535	7,955	136,315
1967	16,572	69,511	23,325	2,779	15,032	9,308	136,527
1968	15,378	73,047	22,354	2,923	15,029	10,036	138,767
1969	14,536	68,306	17,939	2,731	12,339	14,879	130,730
1970	14,149	60,832	19,674	2,681	11,628	14,221	123,185
1971	12,736	54,788	18,374	2,502	10,612	12,962	111,974
1972	11,850	52,300	17,929	2,400	10,197	12,328	107,004
1973	11,094	49,980	17,536	2,339	9,788	11,990	102,727
1974	8,804	46,207	16,560	2,252	9,060	11,351	94,234
1975	11,094	49,980	17,536	2,339	9,788	11,990	102,727
1976	8,374	47,099	16,653	2,206	9,318	11,254	94,904

SOURCES: Fletcher B. Porter, "The USAF Vehicle Procurement Program" (Master's thesis, Air Force Institute of Technology, 1964), p.4, and Larry L. King, "USAF General Purpose Vehicle Buy Program" (Professional Study, Air War College, 1976), p. 26.

satisfy requirements rather than purchasing new vehicles. Even so, Exhibit B shows that procurement has not kept up in recent years to the extent that assets are less than authorizations. Further, the Vietnam War caused many newer vehicles to be shipped to Southeast Asia, where they were worn out through hard usage, destroyed, given to allies, or become uneconomical to transport back to the United States.

Congress has been increasing absolute funding in dollars, and, as Exhibit C shows, the amount of funding is expected to increase. However, inflation has decreased the purchasing power to 65 percent in this program since 1966. A 1/2-ton pickup cost $1,600 in 1966; $3,700 in 1975; and is programmed to cost $4,500 in FY 1977.[8] A comparison of inventory and replacement values in Table 2 shows the increase in price per unit. Despite an increase in funding level, inflation prevents a full procurement of required vehicles. This means that those on hand must serve beyond their projected life span, or units with valid needs must do without vehicles. One indication of the

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[8]Larry L. King, "USAF General Purpose Vehicle Buy Program" (Professional Study, Air War College, 1976), p. 43.

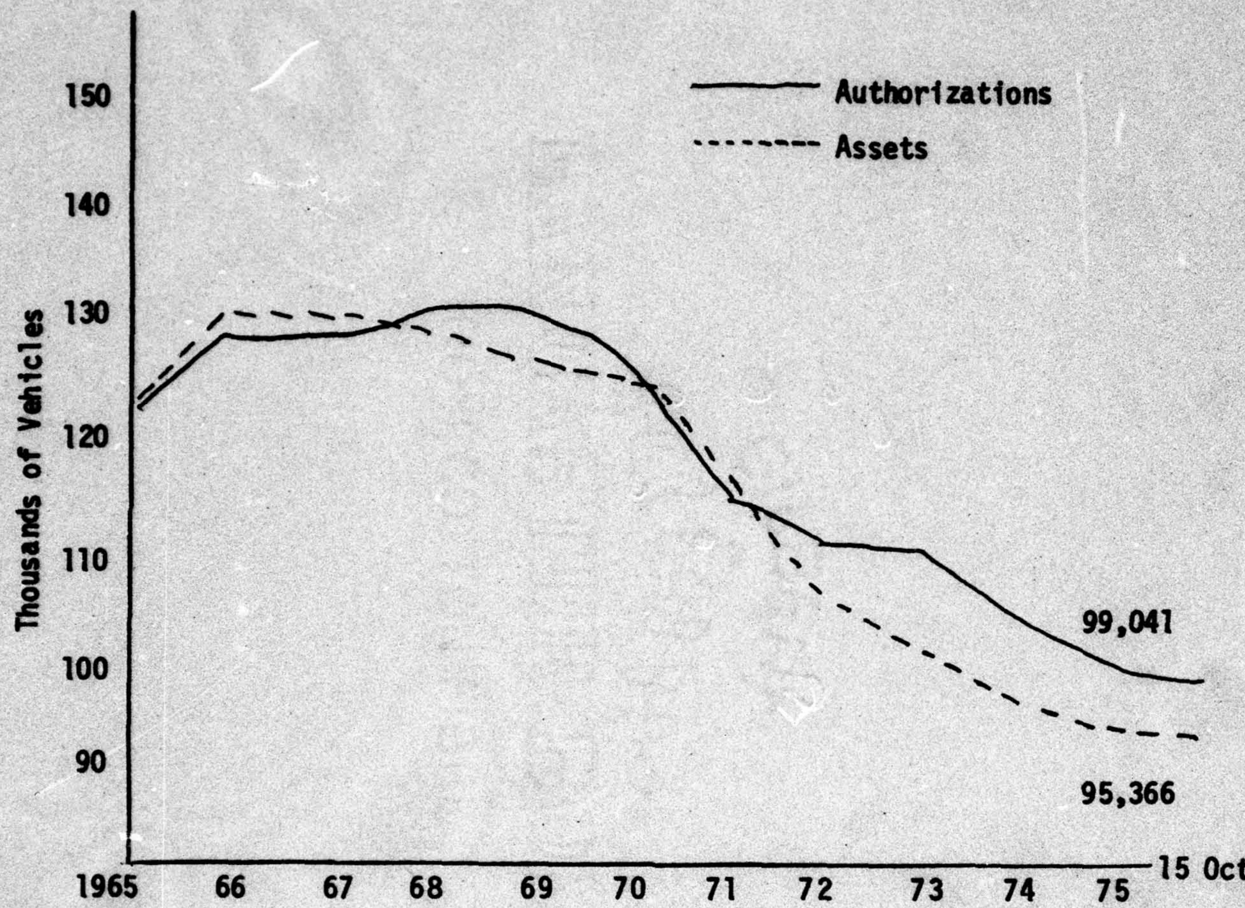

EXHIBIT B

VEHICLE AUTHORIZATION/ASSET POSITION

SOURCE: Larry L. King, "USAF General Purpose Vehicle Buy Program" (Professional Report, Air War College, 1976), p. 28.

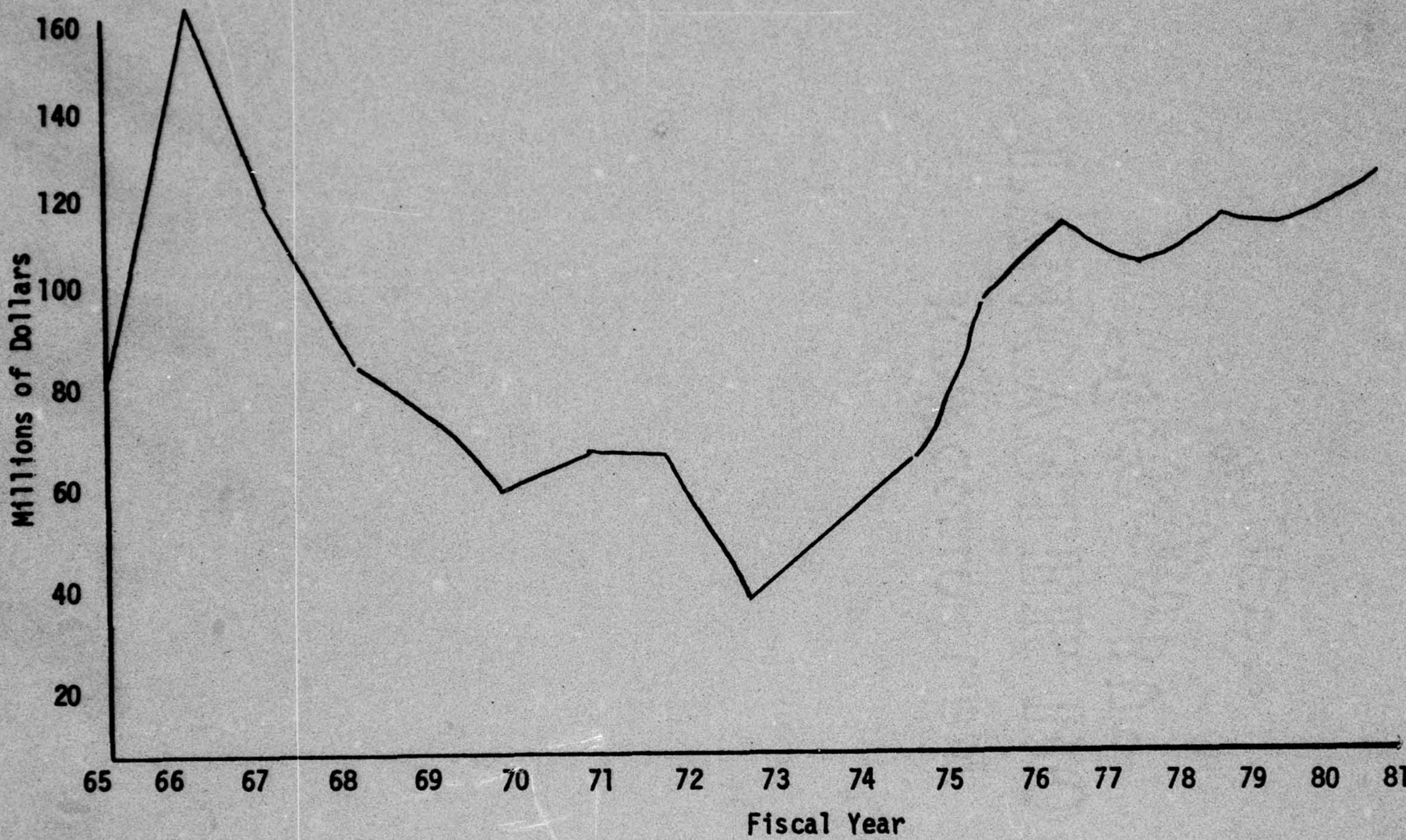

EXHIBIT C

VEHICLE BUY PROGRAM FUNDING A/O 1 DEC 75

SOURCE: Larry L. King, "USAF General Purpose Vehicle Buy Program" (Professional Study, Air War College, 1976), p. 27.

TABLE 2

VEHICLE REPLACEMENT COST

Year	Vehicles	Replacement Cost	Cost/Unit
1969	130,490	$ 826.4 million	$ 6,333[a]
1973	102,727	926.0 million	9,014[b]
1976	97,904	1,320.3 million	13,912[c]

SOURCES: [a]Fletcher B. Porter, "The USAF Vehicle Procurement Programs" (Master's thesis, Air Force Institute of Technology, 1964), p. 3.

[b]Ernst R. Karsten and Larry T. McDaniel, "Suggested Methods for Implementation of Life Cycle Costing Techniques in the Procurement of Air Force General Purpose Commercial Vehicles" (Master's thesis, Air Force Institute of Technology, 1974), p. 1.

[c]Larry L. King, "USAF General Purpose Vehicle Buy Program" (Professional Study, Air War College, 1976), p. 1.

extent of vehicles being uneconomically retained is condition codes. Table 3 shows the codes. One study provides a good summary of how these codes are used.

> Air Force manual 77-1 provides general guidance relating to normal replacement of government vehicles, but the principle guidance is more adequately provided in T. O. 00-25-249, Maximum Repair Allowances, Replacement Codes, and Priority Buy for USAF Vehicles. This publication prescribes the procedures to be followed for determining whether a vehicle is eligible for repair or disposal and how it should be coded for replacement programming. It provides policy, guidance, and procedures to avoid unnecessary expenditures of funds for vehicle repair. This essential guidance greatly simplifies the criteria for replacing the vehicle fleet. The key elements identified in the document are entered into the Registered Equipment Management System (REMS) and are compared with VIMS data to identify an inventory errors in either or both systems. When required, repairs on a vehicle are based upon the maximum one time repair allowance. This is established by considering the miles accumulated on the vehicle or the age and establishing an amount which can be expended. At bases where the maximum one time repair allowance is not automated through sophisticated system programs, manual computations are formulated using the following computations:
>
> $$\text{AGE COMPUTATION} = \frac{\text{Standard Price} \times \text{Years Remaining}}{\text{Life Expectancy Years}}$$
>
> $$\text{MILEAGE COMPUTATION} = \frac{\text{Standard Price} \times \text{Remaining Mileage}}{\text{Life Expectancy Mileage}}$$
>
> The repair allowance should be less than 10 percent of the standard price of a replacement vehicle. Authority for minor repairs rests with the Base Commander, who normally delegates this function to the

TABLE 3

VEHICLE REPLACEMENT CODES

A--Age, Miles, and One Time Repair. Life expectance years and miles have been reached or exceeded and repair estimate exceeds the one time repair allowance.

B--Age and One Time Repair. Life expectancy years have been reached or exceeded and repair estimate exceeds the one time repair allowance.

C--Miles and One Time Repair. Life expectancy miles have been reached or exceeded and repair estimate exceeds the one time repair allowance.

D--One Time Repair. Repair estimate exceeds one time repair allowance.

G--Age and Miles. Life expectancy years and miles have been reached or exceeded.

H--Age. Life expectancy years have been reached or exceeded.

J--Miles. Life expectancy miles have been reached or exceeded.

K--Age and Miles, One Year. Life expectancy years and miles will be reached in one year.

L--Age, One Year. Life expectancy years will be reached in one year.

M--Miles, One Year. Life expectancy miles will be reached in one year.

N--Age and Miles, Two Years. Life expectancy years and miles will be reached in two years.

P--Age, Two Years. Life expectancy years will be reached in two years.

Q--Miles, Two Years. Life expectancy years will be reached in two years.

TABLE 3 (cont.)

VEHICLE REPLACEMENT CODES

R--Midrange. Will be used when a vehicle has reached its midlife cycle.

S--Depot. Will be used for 48 months after depot repair.

T--All Other. Will be used when other codes do not apply.

U--Warranty. Will be used when a vehicle is still under the manufacturers' warranty. R & A will input and remove this code from the vehicle's master record by a (CC) transaction.

SOURCE: U.S. Department of the Air Force, Maximum Repair Allowances, Replacement Codes, and Priority Buy for USAF Vehicles. T.O. 00-25-249, 1 November 1974, pp. 5-1, 5-2.

> Vehicle Maintenance Officer. Major repairs must be approved by the Major Command (MAJCOM) unless the Command has redelegated this authority to the Base Commander. When a vehicle exceeds the age, mileage expectancy, and the maximum one time repair allowance, the vehicle is disposed of in accordance with routine disposition instructions.
>
> Another significant REMS reporting item which must be addressed is the vehicle replacement code. This code system was developed to provide timely programming for new vehicles. The codes are alphabetical indicators and range from the letters U through A. Each letter indicates the general condition of the vehicle and, as the code digresses from U to A, it represents varying degrees of vehicle status. For example: Code U is assigned to a new vehicle which is under the manufacturer's warranty. Code A means that the vehicle has either reached or has exceeded the life expectancy in years and miles, and that the repair estimate exceeds the maximum one time repair allowance. The WRALC (formerly WRAMA) (MMU) monitors all such codes, but increased interest is applied on those with codes A-N. The N coding symbolizes that the maximum life expectancy and miles are forecasted to be reached within two years. This two year indicator is used extensively in estimating the future vehicle buy requirements.[8]

Appendix A gives a review of the current status of the fleet by these codes.

The data used for these codes are not permanent. The life expectancy obviously effects which code a vehicle will acquire, and therefore when it will be replaced. Department of Defense Instruction 4150.4, Replacement and Repair Guidance and Life Expectancies for Commercial Type

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[8]King, pp. 17-19.

Vehicles was a guide, but recent changes in USAF Technical Order 36-A-1-70, Maximum Repair Allowance for USAF Vehicles, show that the number of years, miles, or hours a vehicle should last can vary.[10] The basis for such changes is not clear. Many attempts have been made to produce an algorithm that establishes the point when a vehicle should be replaced. An Army study noted:

> When life expectancy is utilized, equipment is removed from the inventory at the end of its specified lifetime, regardless of condition. In real life, equipment does not wear out in this fashion; the physical environment, usage, and quality of maintenance are weighty factors contributing to its condition at the end of its preestablished paper lifetime.
>
> The requirements model uses the data generated from the effective life model as one of its basic inputs. Previously the effective life model has been used to determine average equipment lifetime, whereas the present study uses the model to determine the distribution of effective life as the base for wear-out rates as well as determining average liftime. Knowledge of average lifetime has been utilized as a base for maintenance, overhaul, and rebuild policies; to improve parts management; and to forecast maintenance workloads. It is true that an estimate of replacement requirements may be made from knowledge of average equipment lifetime. Given an equipment lifetime of five years, one would expect to replace one-fifth of the inventory each year. However, this straight-forward approach has drawbacks. For this figure to be truly indicative of the requirement, the inventory age distribution must be stable

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[10] Ibid.

> from year to year. This implies two things--that the item has been in the inventory for enough years to establish a stable age distribution and that the indicated requirement is procured and introduced into the inventory each year to guarantee continued stability. Many factors in the real world prevent the achievement of a stable age distribution. The schedule for new model introduction into the inventory may delay the point of stability. Activation of new units with their equipment may unbalance the age distribution. Budget and procurement restrictions may be such that replacements are not available when needed, thus distorting the age distribution. A model may not be in the Army inventory long enough to reach stability even with optimum introduction and replacement of equipment. During the first few years after introduction of a new model, replacement will be required only for those items accidentally lost. Thus, some time must elapse before the replacement quantity derived from the average lifetime will be accurate. For these reasons, replacement requirements based on average lifetime are unsatisfactory.[11]

Exhibit D, from the Army Study, is a good example of one of the variations on a theme, where each period's cost is compared to the previous period's cost. The acquisition cost divided by the number of periods can be thought of as depreciation. This cost should decrease with age. At the same time, maintenance cost should increase. At some point, a minimum should be reached, at which time

---

[11]Virginia W. Perry, Joseph A. Dodge, L. Dean Fossum, A. Eugene Havens, and Marion R. Hornes, "A Replacement Requirement Methodology for Procurement of Army Equipment" (U.S. Army Study, 1967), pp. 26-27.

EXHIBIT D

AVERAGE COST-EFFECTIVENESS PER INTERVAL

AFTER SUCCESSIVE INTERVALS OF USE

$$E_1 = \frac{A + C_1}{q_1}$$

$$E_2 = \frac{1}{2}\left[\frac{\frac{A}{2} + \frac{C_1}{2}}{q_1} + \frac{\frac{A}{2} + \frac{C_1}{2} + C_2}{q_2}\right]$$

$$E_3 = \frac{1}{3}\left[\frac{\frac{A}{3} + \frac{C_1}{3}}{q_1} + \frac{\frac{A}{3} + \frac{C_1}{3} + \frac{C_2}{2}}{q_2} + \frac{\frac{A}{3} + \frac{C_1}{3} + \frac{C_2}{2} + C_3}{q_3}\right]$$

$$E_n = \frac{1}{n}\left[\frac{A}{n}\sum_{i=1}^{n}\frac{1}{q_i} + \sum_{i=1}^{n}\left(\frac{C_i}{n - (i - 1)}\sum_{j=1}^{n}\frac{1}{q_j}\right)\right]$$

E_n = Average cost-effectiveness per interval after n intervals of use.

A = Item acquisition cost.

C_i = Total maintenance cost in interval i.

q_i = Effectiveness in interval i.

SOURCE: Virginia W. Perry, Joseph A. Dodge, L. Dean Fossum, A. Eugene Havens, and Marion R. Hornes, "A Replacement Requirement Methodology for Procurement of Army Equipment" (U.S. Army Study, 1967), p. 9a.

the vehicles should be replaced. The difficulty with a model such as this one is that effectiveness is hard to measure. Further, the acquisition cost must be adjusted for price changes, and replacement cost is used instead. In a period of high inflation, the model loses some validity. The maintenance cost is also affected by inflationary wage increases, and assumes that there is no cost in terms of morale, quality, or training.

Another study using a similar model tried to identify the maintenance cost as related to direct labor hours. Lt. Col. Lawrence Hart stated, in part,

> In the development of the model, it was noted that it was not possible to identify the personnel function in relation to the age of the supported vehicles. This feature apparently has not received consideration because of the institutional constraints of the military personnel system. However, in view of the drastic changes which are indicated by the model's solution if there were to be very minor modifications of the discount rate, it is believed that some investigating of the possible effects of a variable personnel rate as a function of the age of the vehicle should be made. Although the criteria manual is not specified in terms of an average age of the vehicles, it is obvious that some average age must have been imputed in the development of these allowances. For it is clear that it will take more personnel to maintain and repair a ten year old vehicle than one only one year old. . . .
>
> The modification to the personnel function, allowing the number of personnel to vary with the age of the equipment, shows that there is a strong possibility that there should be a drastic revision in

> the replacement policies. . . . As would be expected the major influence was shown by the maintenance function. . . .
>
> The dramatic change produced by the modification to the personnel function to attempt to account for the age of the equipment indicates that a serious investigation of this feature should be conducted.[12]

Replacement is not the only way a new vehicle requirement can be generated. Due to changes in mission or location, an organization could develop a new authorization. Table of Allowance 010 gives guidance on how many vehicles an organization should need by type.[13] This level is in the nature of a maximum, and the number of authorizations in TA 010 must be requested and approved separately. One study done on pickup trucks attempted to use regression analysis to determine if there was a relationship between a functional organization and the number of trucks needed. For instance, in transportation squadrons regression was done on mileage, number of dispatches, size of base population, and other variables versus the number

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[12] Lawrence P. Hart, "A Replacement Model for Equipment with a Constant Operating Requirement: A Solution to a Department of Defense Allocation Problem by Tactical Military Vehicles" (Master's thesis, University of Maryland, 1969), pp. 26-27.

[13] U.S. Department of the Air Force, Table of Allowances: Vehicles, T/A 101, 1973.

of pickup trucks actually used. This was done for many different organizations. The result of 228 regression analyses did not indicate a significant degree of relationship between the variables and the number of vehicles authorized except in one minor case.[14] This seems to invalidate the table of allowances, and implies that authorizations are based on the user's opinion. Thus, a decision to purchase a new vehicle against a new authorization is based on the ability of the user to write a sufficiently convincing justification, and have it approved on a subjective basis as the request (AF Form 601A) goes through supply channels, where the final decision is made at the Major Command Equipment Management Office (CEMO).

The result is that a maintenance shop at one base may have a larger fleet of relatively underutilized vehicles than one at another base with the identical mission and conditions. If the maintenance manning is based entirely on numbers, with no regard to degree of usage, there will be a difference in the number of mechanics assigned, although the workload may be similar. Consider

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[14]Donald H. Haraldson, "Analysis of United States Air Force Authorization Criteria for Pickup Trucks" (Master's thesis, Air Force Institute of Technology, 1966), p. 37.

the position of the transportation squadron commander at base level. As the organization with the largest requirement for vehicles, he is in the position to improve maintenance manning by obtaining additional unneeded vehicles. The only limitation is the generous TA 010 standard, and his own persuasiveness.

The current system of vehicle management is an integration of replacement and new requirements. The organizations involved before any procurement action is taken include five levels: Base, Major Command (MAJCOM), Warner Robbins Air Logistic Center (WRALC), Hq AFLC and Hq USAF.

The base has physical control, and record keeping responsibilities. The transportation squadron is tasked with vehicle operations, maintenance, and record keeping related to maintenance. The Chief of Supply, through the Registered Equipment Management System (REMS) administered by the Equipment Management Office (EMO), takes care of vehicle authorizations, and actual control of vehicles issued to organizations throughout the base. The REMS is a computerized record keeper, which includes the replacement codes. The transportation squadron, through the Reports and Analysis Branch, provides

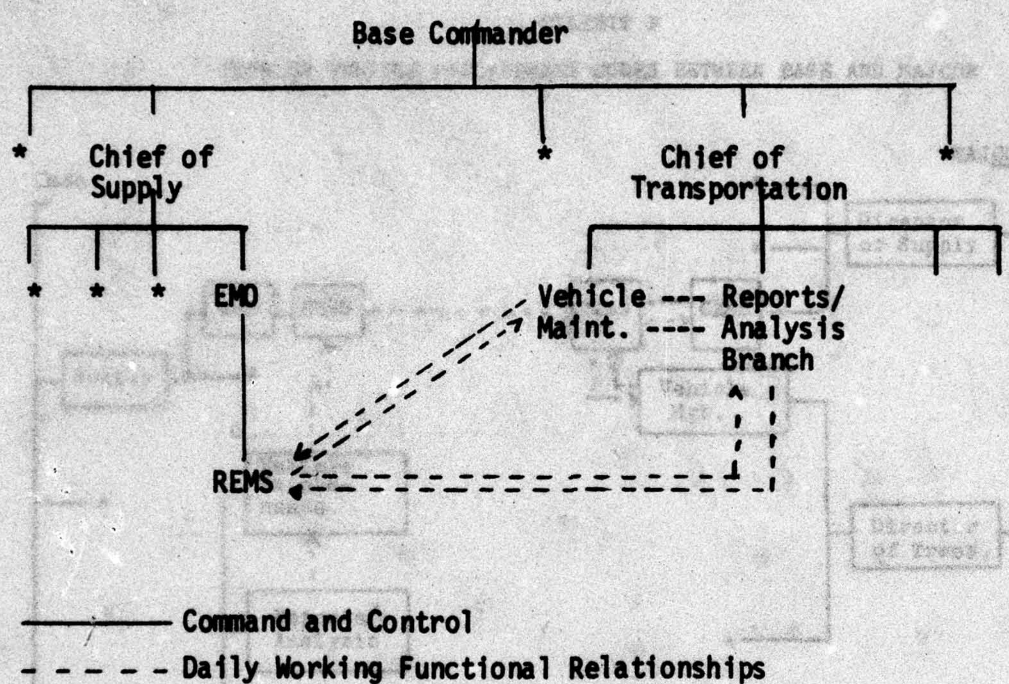
information needed to update the REMS system. Exhibit E shows the relationship.

The MAJCOM responsibilities match those of the base level. The prime tasks are disposition of command assets (although WRALC can do this, also), and record keeping consolidation. The latter task is needed when submitting command priority lists for a buy. This document is used by WRALC for budgeting and buying vehicles, and for distributing new assets. The MAJCOMS prepare these lists using the new authorizations and replacement code data. It is broken out into five increments, by importance. This priority listing is recognition that not all of the request funds will be forthcoming. It is noteworthy that there is no opportunity for an input of the opportunity cost in maintenance of not receiving needed vehicles. The relationship between the base level and the MAJCOM is shown in Exhibit F.

The next level is perhaps the most significant to vehicle management. WRALC, through the Accessories and Vehicle Inventory Management Division (MMU), is the center of the process. Using REMS data and the command priority lists, MMU forecasts and budgets new vehicle purchases. It can also affect the amount of purchases

EXHIBIT E

AGENCIES INVOLVED IN VEHICLE ASSET CONTROL AT BASE LEVEL

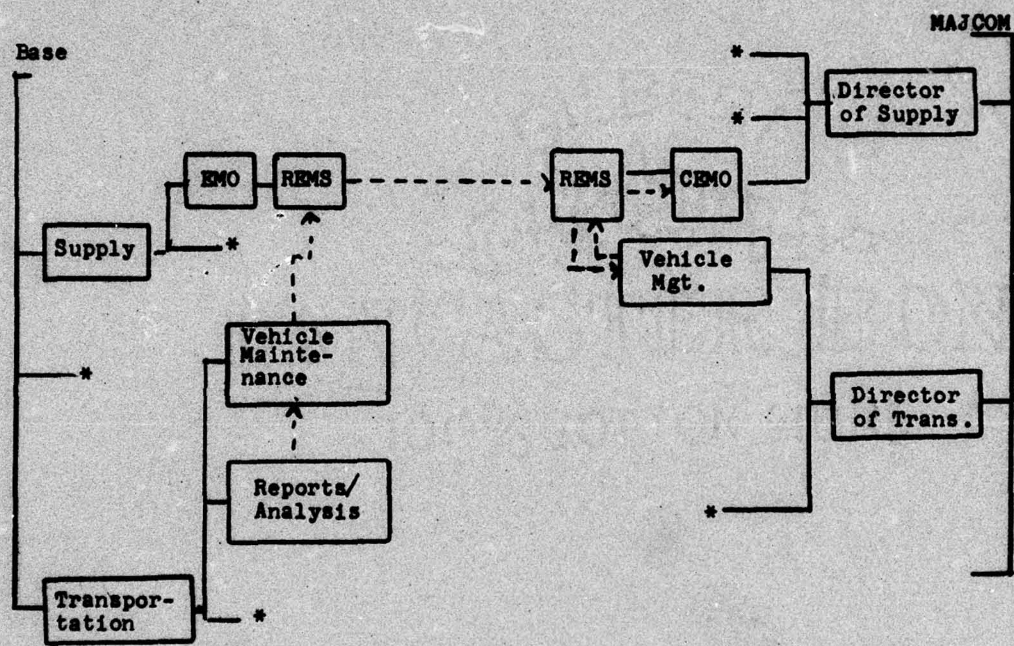


*Other functions would be included in a more detailed organizational chart.

SOURCE: Keith E. Burres and Michael H. Smith, "An Analysis of the Need for Specialized Management of the Air Force Special Purpose Vehicle Fleets" Master's thesis, Air Force Institute of Technology, 1973/, p. 47.

EXHIBIT F

FLOW OF VEHICLE REPLACEMENT CODES BETWEEN BASE AND MAJCOM



------- Flow of Vehicle Codes

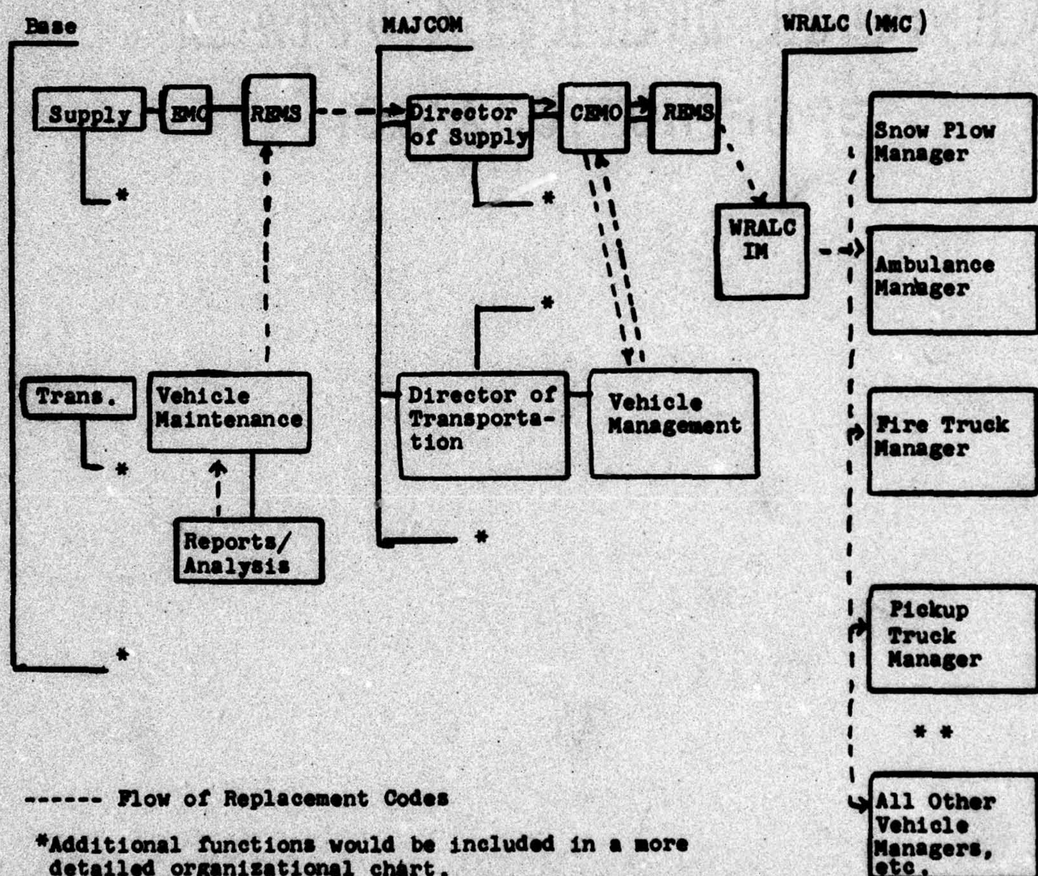
*Additional functions would be included in a more detailed organization chart.

SOURCE: Keith E. Burres and Michael H. Smith, "An Analysis of the Need for Specialized Management of the Air Force Special Purpose Vehicle Fleet" (Master's thesis, Air Force Institute of Technology, 1973), p. 49.

through distribution actions. This applies to both old and new vehicles. As the agency with information on both surpluses and deficiencies, MMU is in position to direct movement of assets from command to command. The maintenance impact of sending older vehicles to a base to satisfy their requirements is apparent. MMU can authorize modifications to vehicles, depot overhaul, and has a capability to solve material deficiency problems. These actions keep older vehicles useful for a longer period. MMU coordinates the final buy list with Hq AFLC and Hq USAF. It processes the purchase requests to the GSA for general purpose vehicles, and makes modifications to the requests as feedback is received on cost. Eventually, it issues shipping instructions, notifies commands, and assigns serial numbers. It should be apparent that the replacement codes are the driving force behind these actions. Exhibit G shows the flow of information of these codes. MMU obviously spends a great deal of effort in analyzing the fleet in terms of these codes, since the budget process requires replacement decisions two years in advance of the need for a physical replacement. Because of this analysis, the development of vehicle equivalents is made at this level. The assignment of these

EXHIBIT G

FLOW DIAGRAM OF VEHICLE REPLACEMENT CODES



------ Flow of Replacement Codes

*Additional functions would be included in a more detailed organizational chart.

**Note: The 5 blocks under the IM at WRALC are merely representative of the many types of vehicles which the IM's manage.

SOURCE: Keith E. Burres and Michael H. Smith, "An Analysis of the Need for Specialized Management of the Air Force Special Purpose Vehicle Fleet" (Master's thesis, Air Force Institute of Technology, 1973), p. 49.

codes according to a GAO review is done on a subjective basis. Historically, the values of the equivalents have changed little, despite changes in age or usage.

The next level of vehicle management has relatively few operational decisions. Hq AFLC makes policy and reviews WRALC actions. Eventually, it is the agency that actually pays the bills after the procurement agency has made the actual purchase.

Hq USAF receives the final buy package and makes the final approval. This level has two interested agencies, the Directorates of Transportation and Supply. Together, they must defend the vehicle funding requirement to DOD, Office of Management and Budget, Air Council, and Congress.

Table 4 gives a summary of the vehicle management responsibilities at each level. It is not always clear where final responsibilities can be assigned, since Hq USAF, Hq AFLC, and WRALC all publish directives that are binding. Further, the division between transportation and supply at each level makes responsibility diffused.

Although the USAF vehicle management agencies have control of the development of requirements, the numbers, types and prices are out of their direct control.

TABLE 4

SUMMARY OF VEHICLE RESPONSIBILITIES AT EACH LEVEL OF MANAGEMENT

Base	MAJCOM	WRALC (MMU)	Hq AFLC (MCSE/MCM)	Hq USAF (AFSSS/AFSTP)
Perform maintenance	Consolidates replacement codes	Consolidates replacement codes	Approves final vehicle buy programs	Provide general guidance
Operate vehicles	Coordinates overhaul actions	Determines vehicle buy requirements		Liaison with Congress monitors
Maintain vehicle records	Maintain command master authorized list	Prepares PR's on buy	Coordinates/approves vehicle budget	
Update replacement codes	Distributes new assets among bases	Distributes new assets among commands	Monitor MMU actions (on staff basis only)	Congressional compliance requirements
		Prepare budget submissions on buys, overhauls and spares		Defends vehicle budget
		Controls overhaul program		
		Redistributes command excesses		

SOURCE: Larry L. King, "USAF General Purpose Vehicle Day Program" (Professional Study, Air War College, 1976), p. 16.

Aside from a relatively few specialized vehicles purchased directly or through the Army, GSA is the prime actor in the procurement process. It is true that Hq USAF and Congress make budgetary decisions that establish the upper dollar limits for vehicle expenditures. The vehicles purchased by the dollars are largely within the discretion of GSA.

The Armed Service Procurement Act of 1947 says "Award shall be made . . . to the responsible bidder whose bid . . . will be most advantageous to the United States, price and other factors considered."[15] Currently, GSA uses only the initial cost as the criteria. Other items are considered on other Air Force purhcases. Major General DeLuca, who was then Chief of Staff, AFLC, and later the USAF Comptroller, stated:

> The objective is to consider fully from the government's standpoint both the cost of acquistion and the cost of follow-on logistics support of an item, in order to make competitive procurement awards on the basis of the lowest total cost of ownership. . . . Greater emphasis will be placed on the latter part of the procurement policy, which states "award to the responsible bidder whose bid will be most advantageous to the Government, price and other factors considered." These other factors (operations and

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[15]Karsten, et al., p. 4.

logistics support) must be calculated to provide information so that the competitive award will result in the lowest ultimate total cost to the Government as distinguished from acquisition price alone.[16]

This concept, called Life Cycle Costing, is used extensively in buying aircraft. If a given vehicle type has a lower total cost than another type, even though it has a higher initial purchase cost, it should be chosen. Exhibit H illustrates the process. The problem is that identification of the follow-on cost is not available to the purchasing agent, GSA, since the data, funding responsibility, and program management are at various levels of USAF Control. The Senate Committee on Armed Services said:

> Take, for example, the contracting officer who determines that a low price is less important in a particular procurement than other valid factors, such as urgency of need, quality of product, or lower ultimate cost. Should he make an award on such a basis to someone other than the lowest bidder, he is immediately placed on the defensive and must justify his actions or might even be personally charged for the apparent excess cost. This attitude has had the only results which could be expected--the award of contracts in a purely mechanical way to the lowest bidder which no exercise of judgment or discretion on the part of the purchasing officer. The committee is firmly of the opinion that this is not in all cases the best way to conduct a business.[17]

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[16]Ibid.

[17]Ibid., p. 48.

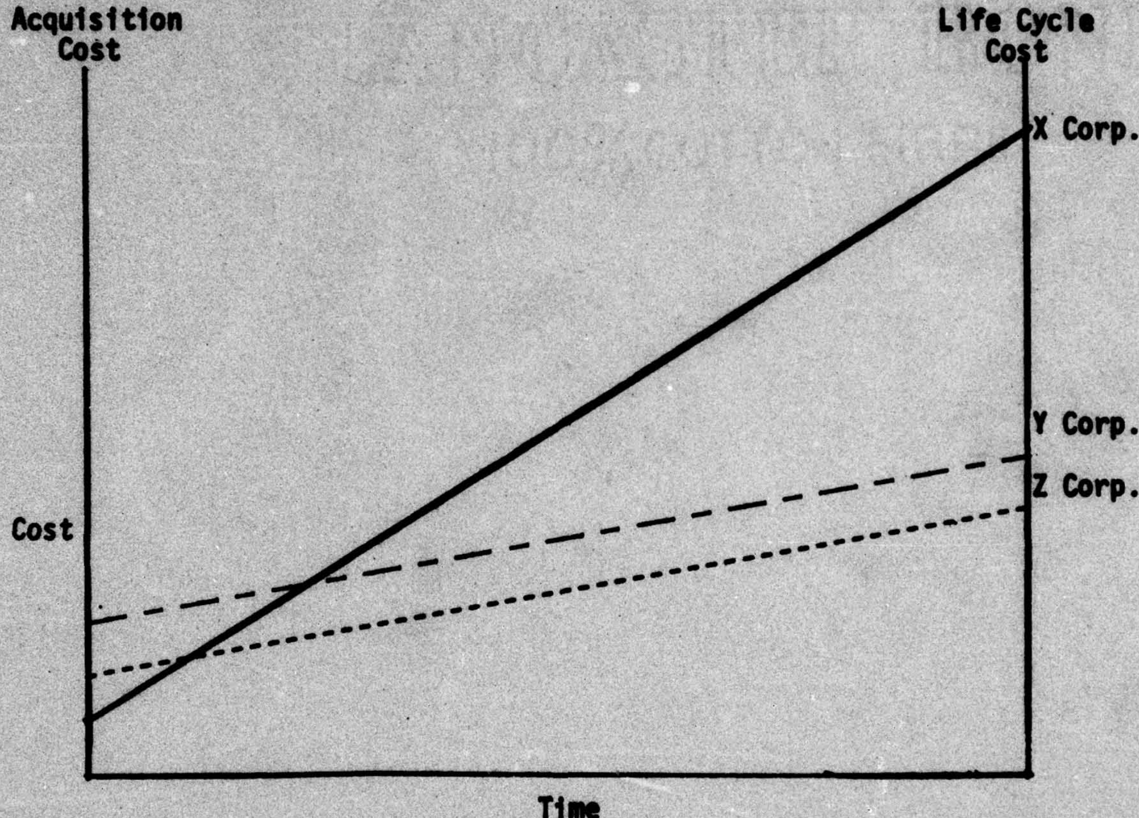

EXHIBIT H

COMPARISON OF HIGH QUALITY HIGH PRICE ITEMS

WITH LOWER QUALITY LOW PRICE ITEMS

SOURCE: Ernst R. Karsten and Larry T. McDaniel. "Suggested Methods for Implementation of Life Cycle Costing Techniques in the Procurement of Air Force General Purpose Commercial Vehicles" (Master's thesis, Air Force Institute of Technology, 1974), p. 30.

Even though Congress seemingly favors more responsive vehicle procurement, it has placed unworkable restrictions on the process. There are maximum prices permitted for bidding, such as $2,100 for a sedan, $2,300 for a station wagon, or $1,650 for a pickup truck. While there is some latitude for options, the low authorizations mean purchases are often negotiated.[18] The cost that GSA can negotiate with manufacturers must be compared with the funding limits and priority lists of MMU. The number and make of vehicles purchased are thus not in direct USAF control.

Some practices cause even the type to be in doubt. The manufacturers often put USAF vehicles at the end of a production run. If it is advantageous, the manufacturer exceeds the minimum specifications of the contract. While eight cylinder engines instead of six cylinder, automatic transmission instead of manual, and other extras at the same price may seem like a bargain, they in fact increase the maintenance complexity of the vehicles.[19] Since the manning standard, vehicle equivalents,

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[18]Ibid., p. 21.

[19]King, p. 45.

is not affected, the manning needs are understated when substitutions of increasing complexity are added.

The type of vehicle would seem to be a decision within the purview of the USAF, but it is not. The manufacturer determines motor, body, capacity, etc. Options, such as transmission, accessories, color, drive wheels, etc. are governed by mandatory DOD approved specifications, which are a result of a joint service review. For instance, the USAF is now worried about pollution control devices, since catalytic converters impose a fire risk on the flight line. This could be an option. The special requirements of vehicles destined for Alaska, or other unusual climates, can be added as options. This is an area where maintenance requirements are considered. For instance, four-wheel drive or air conditioners entitle a vehicle to a slightly higher vehicle equivalent. Not all changes are so effected. Electronic ignition, disc brakes, pollution control devices, automatic transmission, etc., are manufacturer's changes that impact maintenance, but have received no recognition.

The location where a vehicle is sent has a definite impact. The make of vehicle is very important overseas, where contract maintenance, overhaul capability,

etc. may exist for one make, and not another. The time spent looking for or manufacturing parts depends on whether that make is marketed in that area.

The make of a vehicle is important in terms of consistency. Parts, subassemblies, and maintenance techniques are similar for the same type over a period of years and between types for the same make. Thus, parts for Chevrolet sedans are basically the same from 1962-68, while there is also similarity between light trucks, sedans, station wagons, and ambulances.[20]

The availability of many makes and types for nearly identical missions proliferates training requirements and lengthens the learning curve. For instance, there are 95 different forklift makes and types between the 2-6,000 lb. capacity authorized.[21]

In summary, the control over number, price, make, type, and consistency by GSA increases the total cost of vehicle ownership by increasing maintenance. The following conclusions in a Defense Supply Agency report concerns parts, but they could also be applied to maintenance.

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[20]Defense Supply Agency, Report on Commercial Vehicle Supply Support, 1969, p. 167-168.

[21]Ibid., p. 222.

1. There is insufficient control within the Military Services to limit the range of types and sizes of commercially designed vehicles/equipment which are being authorized and procured. This has resulted in proliferation of types, sizes, and models which has seriously complicated the support of commercial vehicles/equipment.

2. Commercial design vehicles/equipment are being procured under performance-type specifications and standards, and the nature of these documents widens the range of potential suppliers with a concomitant adverse effect on standardization. However, the advantages accruing from this overrides the disadvantages and argues for a continued use of performance-type specifications and standards.

3. Although the existing Federal and Military Specifications and Standards for the same type of commercially designed general purpose vehicles are separately developed and requirements are stated differently, they result in delivery of the same basic vehicle, excluding minor options. The effort involved in the separate development of these documents is unnecessarily duplicative.

4. The present practice of procuring commercial design vehicles/equipment by formal advertising results in a proliferation of makes and models within the DoD inventory which serves to complicate supply support. The financial advantages of this procurement technique would continue to be achieved if these buys were made on a multiyear basis, and use of this technique would enhance standardization of commercial vehicles and ease supply support problems.

5. Extremely limited action is being taken to achieve end item standardization by make and model on an installation or geographical area basis. However, the potential in improving end item standardization by controlling deliveries from new procurement is not being realized.[22]

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[22]Ibid., p. 236.

Taken in combination, the system embracing the Congress, GSA, U.S. Army, and five USAF agencies divided functionally between two disciplines has created a diverse vehicle fleet. The justification, numbers, make, type, model, options, distribution, location, age, and usage of this fleet all have an impact on vehicle maintenance, while the quality of the maintenance eventually affects the agencies and the capability of the fleet to perform its designed mission. In the next chapter, the above factors will be shown to have little relevance on the way vehicle maintenance shops are manned.

CHAPTER III

MANNING DETERMINANTS FOR VEHICLE MAINTENANCE

Transportation and manpower experts in the United States Air Force and the Government Accounting Office have been dissatisfied with the current manning within Vehicle Maintenance sections. Both the actual level of manning and the methodology have been questioned. A full-scale study was accomplished in 1967 and forms the basis for the current standards.[1] Since then, there have been changes in the approach used by manpower experts. There is a recognition that the environment in an organization can change rapidly. Missions, methods, equipment, and technology can invalidate the best of studies. Manpower experts can either constantly reaccomplish their studies, or develop procedures that accommodate change. In the vehicle maintenance organizations, there have been changes. The end of the Vietnam conflict, the all-volunteer force, reductions in headquarters supervision, technological changes,

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[1]Stewart AFB ADC Management Engineering Team, "Vehicle Maintenance F.C. 4240 Final Report" (Stewart AFB, N.Y., October 6, 1967), p. 1.

energy shortages, economic decline, inflation, ecology movements--all of these factors have had an effect on manning requirements since the study nearly a decade ago. Realistically, it may be expected that there will be changes in the future. This chapter will explore current manning practices in vehicle maintenance, and suggest a method that might provide a perpetual update of manning standards in this area.

At each USAF base or activity, there is likely to be a collection of blue or yellow vehicles provided for official business. Many of these vehicles, such as sedans, are used for administrative purposes. Most vehicles are needed for work, such as pickup trucks and vans. Official vehicles provide personal transportation in overseas areas which would normally be accomplished by privately owned vehicles. Other vehicles serve very specialized purposes, such as fire trucks, refuelers, and materials handling equipment (MHE).[2]

Two classes of vehicles are maintained by the organizations that operate them. Civil engineering

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[2]U.S., Department of the Air Force, Joint Procedures for the Management of Administrative Use Motor Vehicles, Air Force Manual 77-1 (Washington, D.C.: U.S. Government Printing Office, 1967), pp. 1-3.

vehicles, such as road graders, bulldozers, etc. are maintained by that organization. Aircraft maintenance organizations maintain certain equipment, such as towing tugs, starting units, etc. that are closely associated with aircraft.

The vast majority of vehicles are maintained by the vehicle maintenance section of the transportation unit. In some cases, this work is contracted out. Warranty work, and certain specialities are sometimes done by commercial firms, although the control, inspection, and funding is done by the base vehicle maintenance activities.

Despite these exceptions, the vast majority of work is accomplished in-house. Depending on the size of the fleet, it can be divided into several work centers, such as a tire shop, battery shop, paint shop, etc. In general, most bases separate the work into general purpose and special purpose vehicles. The latter includes fire trucks, MHE, refuelers, etc. More specialized training in hydraulics and electrical systems is required to maintain these vehicles.

Much of the work is similar to that familiar to every car owner. The using organization brings in a vehicle when it is broken or has been in an accident;

however, most people do not maintain a government vehicle as well as they would their own, so vehicle maintenance has a program of periodic safety inspections and a servicing schedule for oil changes. This preventive maintenance takes administrative time, but in the long run saves maintenance manhours. Commercial vehicle fleet operators, such as trucking firms, follow the same policy.[3]

Each base has unique characteristics that cause manning for various organizations to be different. If individual commanders were to have the sole authority to determine manning, there would be considerable inflation of requirements to cover peak work periods. In private industry, forecasts of manpower needs for four months in the future averaged a 7 percent error.[4] Transportation units are no exception. In order to achieve efficiency in the use of manpower resources, an external, unbiased organization determines exactly how many people are required to accomplish a task.

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[3]Charles A. Taff, Commercial Motor Transportation (Homewood, Ill.: Richard D. Irwin, 1961), p. 290.

[4]Robert Ferber, Employer's Forecast of Manpower Requirements: A Case Study (Urbana: University of Illinois, 1958), p. 44.

The USAF Management Engineering Program (MEP) is the means by which manpower requirements are determined, distribution and utilization of resources are managed, and services and studies are furnished to functional organizations to improve management of manpower. Air Force Manual 25-5, Management Engineering Policies and Procedures, states,

> Manpower standards are developed by (1) transforming existing job standards (established by internal work measurement systems) into manpower standards (preferably by work center), (2) conducting work measurements studies to acquire data for direct use in establishing manpower standards, or (3) developing statistical manpower standards from an existing data base.[5]

Management Engineering Teams are established at base level to accomplish these tasks. These teams might be termed efficiency experts. They often conduct time and motion studies, work sampling, and other direct observations to arrive at a data base. The data base is then analyzed using various statistical techniques, including linear regression, multiple regression, nonlinear regression, queing theory, and correlation to determine what

[5] U.S., Department of the Air Force, Management Engineering Policies and Procedures, Air Force Manual 25-5 (Washington, D.C.: Government Printing Office, 1973), p. 1-1.

requires manpower. The result is an estimating equation that establishes the relationship between a "manpower determinant" and workloads. These equations are subject to tests for significance, such as student "T," "F," or Chi-square, and are required to meet minimum standards of coefficient of correlation = .7071, coefficient of determination = .5, with a .95 level of confidence.

When a functional review is made, the procedure usually is for a "lead team" to conduct a preliminary study. Other MET's then collect data at other locations, using guidelines developed by the lead team. These data are then systematically analyzed. If it has wide application, it is published in Air Force Manual 26-3, Air Force Manpower Standards.[6]

One of the important factors in this process is the development of the manpower determinants. The problem is in trying to use these factors for multiple purposes. The primary purpose, and the one that has priority in case of conflict, is to chose a determinant that has the highest probability of correlation with the manning requirements.

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[6]U.S., Department of the Air Force, Air Force Manning Standards, Air Force Manual 26-3 (Washighton, D.C.: Government Printing Office, 1973), p. 4210C-1.

The second purpose is to chose a factor that can be predicted for future time periods. For example, a factor such as "work orders" may be highly related to the number of workers needed in the maintenance control section; it is possible that "base population" is also highly correlated to manpower required. Base population has the advantage of being predictable. It can be used if units are moved, missions changed, bases closed, etc. Using base population as the workload factor would enable planners to accurately predict the manpower effects of various mission changes. This could affect such factors as budgeting or notification of personnel actions. In contrast, work orders are largely a historical data base.

Unfortunately, it is a rare case where factors that are programable or predictable are also the factors that most accurately determine manpower needs. There is usually an inverse relationship between the relative strengths of these two purposes. From the viewpoint of management engineering, there is an understandable desire to use workload determinants that are programable. Manpower requirements can be developed quickly and with little

additional work. More direct factors require elaborate reporting and repetitive analysis.[7]

Within an organization there may be work centers that have basically different tasks. Each work center must be analyzed separately. Appendices B, C, and D describe Management, Maintenance Control, and Maintenance/Repair, respectively, within the vehicle maintenance section of a transportation organization.

The manpower determinant for Management is personnel authorized.[8] The standard manning equation is $y = 1.0551 + .01213x$. The manning chart is shown in Table 5.

This standard appears reasonable. Most management jobs are based on personnel assigned, since direct supervision is their main task, rather than any specific output. The MET study in 1967 arrived at the same conclusions, although a slightly different equation based on manhours was used. That study also considered Vehicles Authorized, Vehicles Assigned (both of these exclude other commands' vehicles, a small detail caused by different reporting systems), Total Vehicles Authorized, Total Vehicles

[7]Kenneth R. Coleman, "The Determination of Manpower Requirements in the United States Air Force" (Professional Report, The University of Texas at Austin, 1974), pp. 23-25.

[8]U.S., Department of the Air Force, Air Force Manning Standards, p. 4240S-2.

TABLE 5

MANAGEMENT AUTHORIZATIONS

AFS	AFSC	Workload Value			
		34	90	179	268
Motor Vehicle Management Officer	6024		1	1	1
Vehicle Maintenance Superintendent	47391	1	1	1	1
Vehicle Maintenance Technician	47 X 71	1		1	2

SOURCE: U.S. Department of the Air Force, Air Force Manning Standards Air Force Manual 26-3 (Washington, D.C.: 1973), p. 4240 S-2.

Assigned, and Personnel Assigned. The coefficient of correlation and determinations was .6062 and .3674, respectively. While not high, or conforming to AFM 25-5 standards, the acceptance was explained away by "investigation of deviate points [which] shows this determination to be significant."[9] Other attempts to explain workload determinates of tasks that largely involve responsibility and supervision of people have had a similar problem in defining exactly what they do. Despite this drawback, the standard appears reasonable and has proved workable in practice.

The Vehicle Maintenance Control Section might be described as first-line supervision. Much of the paperwork, as well as scheduling and inspections, is accomplished in this work center. There are nontransportation specialties assigned, such as inventory management, which controls parts and certain tools.

The standard manning equation is $y = .1034 + .01548x - .000004141x^2$ for vehicle fleets of 1498 and

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[9]Stewart AFB ADC Management Engineering Team, "Vehicle Maintenance F.C. 4240 Final Report," p. 2-1.

below and $y = 2.9958 + .007592x$ for above 1498.[10] See Table 6.

The 1967 MET study was similar. The standard manning equation was $y = 14.680437 + 2.196032x - .000582x^2$ for vehicle fleets of 1421 and below; for fleets above 1421, the formula was $425.41 + 1.0801x$.[11] This produces a man-hour formula rather than personnel authorized, but the formula gives basically the same result as the AFM 26-3 equation. In both calculations, the workload determinant is, "total number of registered vehicles assigned to the Base Vehicle Maintenance function for maintenance regardless of the owning command or using organization."[12] Considering the duties of maintenance control, this is intuitively reasonable. The amount of work is about the same, regardless of the difficulty of actual maintenance. Other workloads examined and rejected were vehicles authorized, total vehicles authorized, total vehicles assigned, AFTO 855 (workorders) completed, line items processed, and

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[10] U.S., Department of the Air Force, Air Force Manning Standard, p. 4240S-5.

[11] Stewart AFB ADC Management Engineering Team, "Vehicle Maintenance F.C. 4240 Final Report," p. 2-1.

[12] Ibid., p. 2-2.

TABLE 6

MAINTENANCE CONTROL AUTHORIZATIONS

	Vehicle Technician	Vehicle Repairman	Apprentice Vehicle Repairman	Inventory Management Specialist	Inventory Management Specialist	Apprentice Inventory Management Specialist	Total
AFS	47x47	47x5x	47x3x	65570	65550	65530	
Workload Values:							
214		2			1		3
294		2			1	1	4
379		3			1	1	5
469	1	3			1	1	6
566	1	3			2	1	7
670	1	3	1		2	1	8
783	1	3	1		3	1	9
911	1	4	1		3	1	10
1058	1	5	1		3	1	11
1238	1	5	1	1	3	1	12
1498	1	6	1	1	3	1	13
1581	1	6	1	1	4	1	14
1712	2	6	1	1	4	1	15
1844	2	7	1	1	4	1	16
1976	2	7	1	1	5	1	17
2108	2	8	1	1	5	1	18
2239	2	8	1	1	5	1	19
2371	2	9	1	1	5	1	20

SOURCE: Stewart AFB ADC Management Engineering Team, "Vehicle Management F.C. 4240 Final Report," p. 2-1.

vehicle equivalents assigned. The correlation of vehicle assigned was .9495 and the coefficient of determination was .9015.[13]

The maintenance/repair work center is the heart of the complex; it is where the actual maintenance is accomplished. There is also a minor maintenance work center, but there is no established standard. Each command can establish its own determinants for this function. The AFM 26-3 standard manning equation is y = 3.4480 + .027901x, with the workload determinant being vehicle equivalents assigned.[14] In the 1967 MET study, the workload factor chosen was Vehicles Authorized. There was very little difference between the correlation and coefficient of determination. For vehicle equivalents, it was .9413 and .8861, respectively, while for vehicles assigned it was .9582 and .9181.[15]

Vehicle equivalents are an attempt to assign a weight to different types of vehicles depending on the

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[13]Ibid., p. 2-8.

[14]U.S., Department of the Air Force, Air Force Manning Standards, p. 4241C-2.

[15]Stewart AFB ADC Management Engineering Team, "Vehicle Maintenance F.C. 4240 Final Report," p. 3-13-14.

level of complexity. Thus, a simple pickup truck is assigned a value of "1." A fire truck has more complicated electrical and hydraulic systems, more tires, axles, etc. and might have a value of "4." Each vehicle has its own equivalent, and it is published in AFM 77-310.[16] Theoretically, a vehicle can gain equivalents. For instance, if an air conditioner is installed in a pickup truck, the equivalent could be raised to 1.1. The problem with vehicle equivalents is its lack of flexibility. In fact, vehicles have grown more complex through the years with the introduction of air conditioning, automatic transmission, electronic ignitions, pollutant emission control devices. The vehicle types are treated as a class, and given the same weight in terms of vehicle equivalents, regardless of additional systems.

Similarly, as vehicles grow older and accumulate mileage, it is reasonable to expect normal wear and tear to exact its toll, and more maintenance would be required. Again, the vehicle equivalents remain inflexible in the

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[16]U.S., Department of the Air Force, Vehicle Integrated Management System, Air Force Manual 77-310, vol. 2 (Washington, D.C.: Government Printing Office, 1974), attachment 3.

face of changing conditions. This has had a definite effect on maintenance. Due to congressional funding limitations, the normal vehicle replacement schedule has not been followed, and the overall age of the fleet has increased. In another situation, the vehicles in the Far East were allowed to age, in part because of the expense of shipping the vehicles, and partially because of the uncertainty of force basing. In both cases, more maintenance was required, while the standard used did not reflect the difference.

The basis for vehicle equivalents is not rigorous. It represents a subjective estimate of comparative complexity. While it is intuitively appealing, the opportunity for a given base to have a misapplication of manpower resource is high. As a fleet ages, and newer, more complex vehicles enter the inventory, it is possible for the entire career field requirements to be understated.

Fortunately, there is an in-being, inexpensive method to statistically measure vehicle maintenance workloads. Since the earlier studies, all USAF bases have implemented the Vehicle Integrated Management System (VIMS). This is an automated information system, using the Burroughs 3500 computer. Information on every USAF vehicle

is included, as well as ongoing updates, such as mileage, costs, and maintenance hours. The validity of using VIMS data is subject to the assumption that the input is accurate. Still, in order to have an impact on final manning, there would have to be widespread collusion among bases to distort the data. Air Force Manual 25-5, Management Engineering Policies and Procedures, permits the development of statistical manpower standards from an existing data base.

Unfortunately, the key piece of information needed to determine the causal factor for maintenance manning is not summarized in existing reports. Each vehicle record includes the number of maintenance manhours expended, but this information is used for other purposes. It is part of the data base at each USAF base, but it is not collected or forwarded.

The location of an air force base should affect the maintenance requirements. The working conditions, in terms of temperature, humidity, or wind should affect the amount of maintenance accomplished in a unit of time. Thus, it might be reasonable to expect that more time would be spent in maintaining a vehicle in 100° temperatures of Southeast Asia than would be spent in a more

temperate environment. Similarly, the location of a vehicle can affect the actual maintenance requirements. Locations near oceans will have corrosion problems; cold weather locations, such as Alaska or Greenland, will have battery problems; locations that have poor roads will have suspension problems. A larger scale study that includes environmental factors would include this determinant.

The list of possible elements available from the VIMS data base was large.[17] The list was narrowed, and will shortly be described, but a brief comment on rejected items may be informative. The condition code of a vehicle describes a vehicle in terms of age, mileage, and cost, in comparison with a predetermined life expectancy. There is some question of the validity of this code, since the life expectancy of each make, in each year, is presumed to be the same. The data on cost are particularly suspect, since it does not differentiate between cost incurred because of parts or labor. In addition, labor cost is allocated by the pay level of the mechanic. Finally, there is no allowance for inflation. Data on cost are more applicable to management and procurement decisions than to manhour allocations.

[17] Ibid., pp. A3-1-A3-5.

The skill level of mechanics obviously affects the manhours spent. Apprenticeship in automotive repair is three to four years.[18] A base that has a level of lower skilled personnel would expect to require more manhours. "A large portion of the skilled manpower in the armed forces leave after one term,"[19] was the finding of a 1954 study, and it has remained true until today; however, the all-volunteer force (which did not directly affect the USAF, since it was mostly volunteer all along) raised wages. A level of high unemployment in the economy can act as a retention aid, and thereby increase experience and reduce manhours. There is a measure of the skill of the workforce in the VIMS data base. The level of skill is taken into consideration by manpower personnel in scaling the numbers. To change the manning requirements to take into consideration fluctuations in personnel assignments, recruitment, and retention rates is theoretically valid, but not practical. It is the duty of manpower to determine requirements, and the duty of Personnel to fill those requirements.

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[18] National Manpower Committee, A Policy for Skilled Manpower (New York: Columbia University Press, 1954), p. 117.

[19] Ibid., p. 225.

Use is another factor that could affect maintenance requirements, but was rejected. It is true, for instance, that a munition squadron's forklift might be subjected to heavier strain than a general supply squadron's forklift. An on-base pickup truck may, in general, travel slower than one that frequently makes off-base trips on high-speed freeways. While use, in terms of mileage or hours, was considered, the type of use was not. First, one of the differences is environment (such as road condition) and could not be determined unless location differences, as suggested for weather conditions, were included, which is beyond the scope of this study. Second, differences in vehicle use on a given base can be, and often are, changed by rotation of vehicles between units via a Vehicle Utilization Board. This rotation tends to make the condition of vehicles "average" on a given base.[20] Thus, while there may be differences between bases, a given base will tend to blur distinctions between use of vehicles.

The measures often used by vehicle managers in evaluating the efficiency of the maintenance are Vehicle-Out-of-Commission (VOC), Vehicle-Down-for-Parts (VDP), and

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[20]U.S., Department of the Air Force, Joint Procedures for the Management of Administrative Use Motor Vehicles, p. 55.

Vehicle-Down-for-Maintenance (VDM) times. VDP is primarily a function of the supply system. In essence, no work is being done on a vehicle while a part is being ordered. This also is included in VOC time. Obviously, manning should not be based on a measure where no work (at least by vehicle maintenance personnel) is being accomplished. VIM comes closer, since it measures the time a vehicle is in a shop awaiting maintenance, with no delays for parts. Clearly, this is a useful tool for management. But since it is a 24-hour-a-day measure, seven days a week, it is not useful for workload measurements. A vehicle turned into the shop on Friday afternoon may accumulate over 60 VDM hours before any work is done on it. A high VDM rate indicates a problem, but it may, or may not, involve manning.

Many of the standard factors used, such as base population or aircraft, were rejected out of hand as inappropriate during the 1967 study.

Although limited by sample location, sample size, and time, this study provides many of the more likely factors in creating maintenance demand. First, each type of vehicle was analyzed separately. This analyzation allows discrimination between makes and vehicle complexity. The dependent variable is Direct Maintenance Manhours. While

there is an existing USAF report, RCS:NAF-LOG(Q)7110, that provides labor hours by vehicle management code (vehicle type, i.e., 1/2 ton pickup, light sedan, etc.), this would not give information on individual vehicles. A subroutine was used on the VIMS data base to accumulate the labor hours on each workorder for each vehicle during the previous 12 months.

The first independent variable tested was vehicle equivalents. This was done primarily to test the effectiveness of the present standard. The Government Accounting Office, in a review of "Maintenance Management of Commercial Type Vehicles," found the use of vehicle equivalents to determine vehicle maintenance manning was ineffective. The reasons for this conclusion were the arbitrary selection of the base vehicle equivalent, the lack of information pertaining to what maintenance functions were included in the vehicle equivalent, and the lack of information on how the number of equivalents which one mechanic should maintain was determined.[21]

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[21]Interview with Major John A. Reidy, Jr., Headquarters, United States Air Force, Washington, D.C., September 30, 1975.

Despite this criticism, it has been the accepted standard for several years. At many locations, it apparently produces a satisfactory manning level. Even if subjective, it may, at a given time, with a fleet of a certain composition, give a high correlation with manning. Hopefully, other, more causally related factors will be found but unless they can explain manning requirements better than vehicle equivalents, the current standard should not be rejected.

The first of these factors is age. The first two digits of the vehicle registration number provide the model year. Since a given vehicle may come from the beginning or, more typically, the end of a production run, and the production run itself may come at different times in the model year, the actual age of vehicle, as determined by the registration number, is subject to variation. It is still a useful measure of age. Many of the maintenance requirements are directly related to only age. For instance, during the first year, warranties cover some of the maintenance. Because of the vehicle rotation policy, mileage differences among older vehicles can be minimized, and age may be the major difference. Certain items, such as paint or batteries, have breakdowns measured in times rather than use.

(1) Age as a variable also serves to differentiate vehicles. As mentioned previously, age will often indirectly take into consideration the manufacturer. It will also include factors of equipage. New vehicles have the more complex systems, such as air conditioning, automatic transmission, and so forth. By identifying the model year, the other variables are included, without having to be specifically identified.

(2) Another independent variable investigated is cumulative mileage. Many factors affecting maintenance are related to total use. At a certain point, parts begin to wear out. As a vehicle approaches high mileage, more and more parts will give out, and a vehicle will come into the shop for maintenance more often.

(3) Directly related to both age and cumulative mileage variables is the expected life. If a vehicle is expected to last six years or 72,000 miles, it is reasonable to assume a vehicle 6 years old and having traveled 60,000 miles will have more maintenance needs than one 2 years old with 25,000 miles on it. Total mileage, or age, may not explain the full characteristics of a vehicle. Certain heavy duty vehicles have comparatively long lives and high mileage life cycles. A bus with only 60,000 miles

on it may be comparatively young, and require less maintenance than a sedan with the same mileage. The condition codes use this comparison between current age and mileage with expected life.[22] The condition codes, being alpha characters, were not useable in regression analysis, so a percentage of life consumed factor was made for both age and mileage. There is some doubt as to the validity of these factors, because of the figures used for expected life. All vehicles within a vehicle management code are assigned the same expected life factor. Thus, a 1967 Ford and a 1975 AMC sedan share a 6-year, 72,000-mile life expectancy, despite differences in weight, engine size, equipment, fuel, and manufacturer. Despite this suspicious factor, it is included since condition codes are currently the most widely used measure of differences in vehicles.

(4) Another independent variable investigated was the <u>mileage</u> in the measurement period. This might be called <u>"current" mileage</u>. It attempts to measure the degree of use. For instance, vehicles located at missile units tend to accumulate mileage very quickly in covering

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[22]U.S., Department of the Air Force, <u>Data Elements and Codes</u>, Air Force Manual 300-4, vol. 7 (Washington, D.C.: Government Printing Office, 1972), p. 7-60.7.

the hundreds of miles between sites. This mileage affects use items, as differentiated from the wear items, that cumulated mileage may measure. Oil changes, tune-ups, tires, etc. could be expected to vary with the level of use. A small number of miles in the last year would indicate infrequent use. More significantly, a large amount of mileage in the last year would indicate many hours of driving per day, with heavy demands on cooling systems, lubrication, and interiors.

Each of these independent variables was evaluated in combination with others in multiple regressions analysis. Each was evaluated separately using linear and non-linear models. At the outset, there was no preconceived theory of the correct model.

This model provides only a partial solution. In actual use, a separate equation would be created for each type vehicle. An analysis section could apply the vehicle fleet at a base, with its characteristics, against the equations. This would provide the manning needed at a given time. As the fleet changes, the equations will change. Thus, if the vehicle buy authorized by Congress were to be increased, the age and mileage of the fleet would decrease, and the equations describing manning would

indicate fewer requirements. Also, if personnel retention were to be higher due to the economy, experience would increase, and the equations should indicate fewer manning requirements.

The equations would provide the direct manhours. The conventional indirect manhours used for such factors as Personnel/Rest Time, delay time, housekeeping, and training would be added. This would provide the total manhours per work center. This figure would be divided by the available workhour figures. This figure is normally 142 hours/month for the military and 149 hours/month for civilians, although AFM 26-3, vol. 1 provides for higher rates in wartime, and some isolated overseas areas.[28]

These equations would be the result of a single report generated from an existing data base. The formulas could be constantly updated, using an enlarged version of this model. In summary, with some programming, a system that is geared to change automatically could provide both updated standards and updated manpower requirements for every base on a periodic basis. Aside from the initial

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[28]U.S., Department of the Air Force, Management Engineering Policies and Procedures, p. 1-3.

programming, this could be done without any additional work from anyone. This system would reduce the requirement for Management Engineering Team visits, and provide a more accurate statement of manning needs at every USAF installation.

CHAPTER IV

ANALYSIS

The previous chapters described deficiencies in vehicle requirements, procurement, and management which affected the manpower needed to maintain the USAF fleet. It should not be assumed, however, that vehicle managers are unaware of these factors. The problem has been one of associating a manpower determination methodology with these factors. The extent to which the Air Force already recognizes the effect of factors other than vehicle equivalents can be seen in a computerized management report, RCS:HAF-LGT (Q&A) 7110. An extract of this report, in a slightly different format, is provided in Appendix A. An analysis of this extract, as well as certain features of the full report, provides insights into the extent of vehicle managers' insights, as well as confirming earlier statements on the nature of the fleet.

The original report provided more detail, breaking out vehicle data by condition code. This extract merely divides the vehicles into broad classes of A-J and K-U, which can be thought of as "relatively old" and

"relatively new," respectively. An "N/A" means that the vehicle possesses neither an hourmeter or odometer; consequently, information on the number of direct maintenance manhours per 1000 miles or 100 hours is not available. These vehicles are generally types that have no internal motive power, such as trailers. They also tend to have very low maintenance requirements.

A dash (-) or blank means there were no vehicles of that type, or no maintenance performed during the time period, FY 75.

The extract rearranged the order of vehicles from the original report by grouping them into categories by their assigned vehicle equivalent.

The first thing to notice is the large number of vehicle types. In fact, the original report contained approximately 140 additional vehicle types for which the exact vehicle equivalent could not be determined. Many of these vehicles are very close in function, and the proliferation of types undoubtably increases the maintenance (as well as supply costs). Within a vehicle equivalent category, there is a noticeable tendency for small inventory sizes to have higher average manhour requirements than large inventory size vehicle types. It is

It is obvious that they do not. If vehicle condition has no effect, then columns 3-6 and 4-7 should be similar, within a given vehicle type. Again, it is obvious that they are not. On the other hand, if amount of use affects maintenance, then columns 3 and 6 would both be similar. With the exception of a few vehicle types with small sample sizes, the range of manhours per 1000 miles or 100 hours is concentrated between 7 and 10.

Although there are certain exceptions, this general pattern is repeated with other vehicle equivalent categories. One notable feature is that the average manhours per vehicle might have a larger range in higher vehicle equivalent categories, such as 2.5, but the average is not noticeably larger than in the lower category, 1.0. The average manhours per vehicle per 1000 miles or 100 hours is noticeably larger in large vehicle equivalent categories. This suggests that there is some surface validity to the notion of scaled levels of maintenance difficulty; however, it is because vehicles in higher categories have less use.

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The fact that Headquarters, USAF maintains vehicle records in this manner shows they are aware of these relationships. There are additional features in

the original report that emphasize this awareness. For instance, there is a summary that compares categories A-J versus K-U. There is also a comparison of various commands' experiences. This is fairly importance. For instance, in B204, pickup trucks, the average manhours in one command is 77.3, while in another it is 25.9. Undoubtably, even wider ranges could be obtained if individual bases were considered.

In summary, then, even an unrigorous examination of the fleet data shows the following factors:

A. There are many vehicles, perhaps too many to deal with in a precomputer-assisted management age.

B. Many vehicle types have small levels of inventory which tend to increase maintenance time, but this fact must be tempered by their lack of use.

C. Vehicle condition, as reflected by gross condition code categories, does affect maintenance requirements.

D. Vehicle use, as indicated by average maintenance per vehicle per 1000 miles or 100 hours, narrows the variance between vehicle types. It also allows comparison between vehicle equivalent

categories. Many vehicles, unfortunately, have no provision for measuring use.

E. Vehicle equivalents have very little relationship with manpower, unless use is considered. Significantly, use is not a factor in the official manning determination.

F. There is considerable variation, in manhours, no matter how the data are grouped by use, condition, type, sample size, or command.

It might be expected that older, more worn vehicles would require more maintenance than newer ones, and this is often the case--as comparison of A-J and K-U categories shows; however, in many cases, it is not true. A trend found in the report and later confirmed graphically using sample data comparing age and manhours showed that the average manhours per vehicle is often lower in the older vehicles, but the manhours per vehicle per 1000 miles or 100 hours is actually higher. This indicates that older, worn vehicles are not as intensively used as newer ones. There are several possible reasons for this situation. One observation is that many defects on a new vehicle which is brought in for repair may be

ignored on older vehicles. Human nature also affects the relationship, since people tend, when given a choice, to prefer to use a new model vehicle over an older one.

While the vehicle management report provides valuable insights, it is grouped data, and as the variance between commands showed, there is a possibility for averages to be misleading. Using data on individual vehicles, it was possible to use regression analysis to provide a more definitive description of the exact nature of factors that impacted on maintenance. The data were obtained from bases shown in Appendix E with the following program:

```
        SOURCE COMPUTER.  B3500.
        OBJECT COMPUTER.  B3500.
    INPUT-OUTPUT SECTION.
    FILE-CONTROL.
        SELECT TAPE-IN ASSIGN TO TAPE-9.
        SELECT CRD-OUT ASSIGN TO PUNCH.
        SELECT SO-DISK ASSIGN TO DISK.
    DATA DIVISION.
    FILE SECTION.
    FD TAPE-IN VALUE OF ID IS "ARAM7A."
```

```
01 TREC-1.
    03 FILLER           PIC XX.
    03 REGNO.
       05 YR-PRO        PIC 99.
       05 REST          PIC X(6).
    03 MGT-CDE          PIC XXXX.
    03 FILLER           PIC X(25).
    03 LIFE-EXP         PIC 999.
    03 FILLER           PIC XXXX.
    03 AGE-EXP          PIC 99.
    03 BASE             PIC XXXX.
    03 FILLER           PIC X(25).
    03 EQV              PIC 999.
    03 FILLER           PIC X(115).
    03 CUMILE           PIC 999999.
    03 FILLER           PIC XXXXXX.
    03 MIL-PER          PIC 9999.
    03 FILLER           PIC X(129).
    03 MAN-HRS          PIC 9999.
    03 FILLERS          PIC X(356).
SD  SO-DISK VALUE OF ID IS "ANFC5S" FILE CONTAINS
    20 BY 1000 BLOCK 10.
```

```
01    S-REK.
      03 MGT-CDE             PIC XXXX.
      03 YR-PRO              PIC 99.
      03 BASE                PIC XXXX.
      03 EQV                 PIC 999.
      03 SUM-M-P             PIC 999999.
      03 CUMILE              PIC 999999.
      03 AGE-EXP             PIC 99.
      03 LIFE-EXP            PIC 999.
      03 MAN-HRS-O           PIC 9999.
FS    CRD-OUT VALUE OF ID "ANFC5C."
01    CRDREC.
      03 FILLER              PIC X VA SPACE.
      03 MGT-CDE             PIC XXXX.
      03 YR-PRO              PIC 99.
      03 BASE                PIC XXXX.
      03 EQV                 PIC 999.
      03 SUM-M-P             PIC 999999.
      03 CUMILE              PIC 999999.
      03 AGE                 PIC 999.
      03 A-L-EXP             PIC 9V99.
      03 M-L-EXP             PIC 9V99.
```

```
    03 MAN-HRS-O          PIC 9999.
    03 FILLER        PIC X(41) VA SPACE.
WORKING-STORAGE SECTION.
01 HOLD-REC.
    03 MGT-CDE              PIC XXXX.
    03 REGNO.
        05 YR-PRO           PIC 99.
        05 REST             PIC X(6).
    03 BASE                 PIC XXXX.
    03 EQV                  PIC 999.
    03 SUM-M-P              PIC 999999.
    03 CUMILE               PIC 999999.
    03 AGE-EXP              PIC 99.
    03 LIFE-EXP             PIC 999.
    03 MAN-HRS-O            PIC 9999.
PROCEDURE DIVISION.
SORTING SECTION.
010-BEGIN.
    SORT SO-DISK ASCENDING MGT-CDE IN S-REK
                 ASCENDING YR-PRO  IN S-REK
        INPUT PROCEDURE IS GET-REK
        OUTPUT PROCEDURE IS GOT-REK
    STOP RUN.
```

```
GET-REK SECTION.
010-START
     OPEN INPUT TAPE-IN.
020-SW.
     MOVE 1 TO SW1.
     MOVE SPACES TO S-REK HOLD-REC.
030-READIN.
     READ TAPE-IN END CLOSE TAPE-IN WITH LOCK
         GO TO 090-END.
040-WORK.
     IF SW1 = 1 PERFORM 050-SETUP TO GO TO 030-
          READIN.
     IF REGNO IN TREC-1 = REGNO IN HOLD-REC
     PERFORM 060-FIGURE GO TO 030-READIN.
     IF MAN-HRS-0 IN HOLD-REC EQUAL 0 OR SPACES
     MOVE 1 TO SW1 PERFORM 050-SETUP GO TO
          030-READIN.
MOVE CORR HOLD-REC TO S-REK
     MOVE YR-PRO IN HOLD-REC TO YR-PRO IN S-REK
     GO TO 040-WORK.
090-END.
     MOVE CORR HOLD-REC TO S-REK
     MOVE YR-PRO IN HOLD-REC TO YR-PRO IN S-REK
          RELEASE S-REK.
```

```
GOT-REK SECTION.
010-START.
     OPEN OUTPUT CRD-OUT.
020-WRYTOUT.
     MOVE SPACES TO CRDREC.
     RETURN SO-DISK END GO TO 080-END.
030-DO.
     SUBTRACT YR-PRO IN S-REK FROM 76 GIVING AGE.
     COMPUTE A-L-EXP = AGE  / (AGE-EXP IN S-REK -
          YR-PRO IN S-REK).
     COMPUTE M-L-EXP = (CUMILE IN S-REK * .001)/
     (LIFE-EXP IN S-REK).
     MOVE CORR S-REK TO CRDREC
     WRITE CRDREC
     GO TO 020-WRYTOUT.
050-SETUP.
     MOVE CORR TREC-1 TO HOLD-REC
     MOVE MIL-PER TO SUM-M-P IN HOLD-REC
     MOVE MAN-HRS TO MAN-HRS-O IN HOLD-REC
     MOVE 0 TO SW1.
060-FIGURE.
     MOVE CUMILE IN TREC-1 TO CUMILE IN HOLD-REC
     ADD MIL-PER TO SUM-M-P IN HOLD-REC
```

```
        ADD MAN-HRS TO MAN-HRS-O IN HOLD-REC.
    080-END.
        CLOSE CRD-OUT WITH RELEASE.
    END-OF-JOB.
```

This program produces a data card with the following elements:

Column 1-4:	The vehicle type code
Column 5-6:	The year the vehicle was purchased
Column 7-10:	The code for the vehicle's location
Column 11-13:	The assigned vehicle equivalent
Column 14-19:	The mileage/hours accumulated in the last year
Column 20-25:	The total mileage/hours accumulated on the vehicle
Column 26-28:	The age of the vehicle
Column 29-31:	The amount of the age life expectancy of the vehicle used (percentage)
Column 32-34:	The amount of the mileage hours life expectancy of the vehicle used (percentage)
Column 35-38:	The direct maintenance manhours accumulated in the past year.

Initially, there was no notion of the type of relationships that might exist. Certainly, logic and

examination of the vehicle management report suggested that condition and use would be important, as well as location. When put on a graph, though, the extreme variance of data did not indicate any clear relationships, except for showing that use of older vehicles declined.

With no clear direction, all of the variables were tested, using straight-line and curved models. Various combinations were tested in multiple regression models, although it was obvious that covariance would be a problem.

For instance, it is the policy for vehicles to be rotated on bases according to use, so age and total mileage would naturally be highly related. Another example is that age, and the condition codes that reflect the degree of lifetime completed based on age would be highly related. The same fault affects total mileage and condition codes that affect lifetime completed based on mileage.

Despite these problems, an across the board analysis was conducted. The regression program, SFIT, available in the OMNITAB II system was used. The notation for a straight-line equation is $Y = B_0 + B_1X_1$, where Y would be manhours, B_0 would be a constant and B_1 the

coeffcient for the variable being tested. In the interest of brevity, only the summaries of data will be shown for pertinent variables.

The most informative description is the R^2 (Coefficient of Determination), since this shows the explanatory value of the regression equation. The "F" value is an indication of the significance, or confidence, that can be placed on the conclusion that there is a relationship. The very high "F" value obtained with fairly large samples indicates a confidence much greater than 99 percent. Due to the bulk of data, pure error was not calculated. In some cases, such as when vehicle age was used as an independent variable, there were many repeat observations and pure error could have been used to form an estimate of σ^2. It is entirely possible that a given model is not the best possible model. Hopefully, the ease of computation and the sufficiency of the model overcome this defect.

The first variable tested was vehicle equivalent, using a straight-line model. This is what is currently used in determining manpower when comparing manhours on the basis of observed work samples, and vehicle equivalents at each base. Using a sample of

1158 vehicles from a cross section of vehicle types, the following result was obtained:

Column	Coefficient	Standard Deviation of Coefficient
B_0	24.058532	4.3573090
B_1	19.306102	1.2051150

Residual Standard Deviation	87.311481
Degrees of Freedom	1158 - 2 = 1156
Residual Variance	7,623.2947
R^2	.18167672

Column	Sum of Squares
B_0	7668531.8
B_1	1956477.7
Residual	8812528.7
Total	18,427,538

$S^2 = 7623.3$ $F = 256.64$

The low R^2 value seems to confirm previous conclusions that vehicle equivalents is a poor predictor of maintenance manhour requirement. If this study has no other value, it should provide support for the rejection of this determinant from manpower requirement development.

When testing other variables, it became immediately apparent that samples taken across the board from all vehicle types would lead to erroneous results. For instance, a comparison of 10-year-old trailers and

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similar forklifts would show a high difference in maintenance requirements based solely on function. Therefore, other variables were analyzed within vehicle types, rather than across vehicle types.

The results were not encouraging. While there was often a strong relationship between predictors and manhours, none consistently met the USAF standard for R^2 of .5. In fact only occasionally did <u>any</u> predictor meet this standard. After 64 runs, using only four vehicle types, no pattern was found that always described a significant relationship; the best predictor was a straight-line, multiple-regression model using age and mileage hours within the last year as predictor variables.

Management Code	R^2
B-152	.4173
B-204	.3551
C-322	.2541
L-273	.0563

This confirms an observation from the vehicle management report: there is a great deal of variability in data. Despite the fact that large samples were used, the variability prevents developing a clean model. Vehicle types with very small sample size would show even more variability.

It is possible that although each individual vehicle type cannot show a significant relationship, the fleet as a whole can. Using the following relationship, residuals were analyzed:

$$R^2 = \frac{\left(\Sigma Y_i^2 - \frac{(\Sigma N\bar{Y})^2}{\Sigma N}\right) - \Sigma(Y_i - \hat{Y}_i)^2}{\Sigma Y_i^2 - \frac{(\Sigma N\bar{Y})^2}{\Sigma N}}$$

The result was an R^2 with an acceptable value of .59. But, it was noticed that recent usage alone had nearly the same explanatory value. The slight increase in the R^2 value might be caused solely by addition of an additional variable. The following data were used in this calculation.

Management Code	N(Sample size)	$\Sigma(Y_i-\hat{Y}_i)^2$	ΣY_i^2	$N\bar{Y}$
B-152	246	356394	1421411	11989
B-204	385	397803	1003325	14442
C-322	106	267274	1063369	19129
L-273	130	2676994	7720065	6070
	867	3698465	11208169	51630

This produces an R^2 value of .545, which is lower but still acceptable. As more vehicle types are added, the R^2 value can be expected to rise.

This result is in agreement with the observation of the vehicle maintenance report, which showed that usage-modified manhours (columns 3 and 6) narrowed the variance of the data.

The usefulness of this finding is subject to some assumptions. It is possible that a regression equation could be made for each vehicle type, but the fleet, as a whole, would point the way toward more accurate manpower determinants. There might be considerable variation and possibility for error on any given vehicle type. This would be especially true for unique, small sample-size type vehicles.

The primary drawback is that many vehicles have no measurement capability. For these vehicles, no regression equation would be possible. Fortunately, these vehicles generally have small maintenance requirements and little variation. Manpower for these vehicles might be developed from a simple average manhours per vehicle basis.

It should be noted that the raw data had many errors. "Garbage in, garbage out" has been a frequent complaint of reliance on computerized data systems, and VIMS data appear to be no exception. Nearly 20 percent of the data were unusable. This inaccuracy level will have to be improved before a reliable system can be used. Further, it will not take long before shop personnel attempt to inflate work order manhour reporting, since this will tend to improve manning.

In spite of the difficulties, it appears that a near-automatic self-adjusting, computerized method for determining vehicle maintenance manpower requirements can be developed. It is clear that the present determinant is both inaccurate and inadequate; therefore, the proposed system, despite certain problems, will be an improvement.

CHAPTER V

SUMMARY AND CONCLUSIONS

An inspection of the vehicle maintenance shops at most USAF bases would show a great deal of activity. It might well be a high-speed production line. The vehicles on the base do not show this degree of care. This seeming incongruity could be explained by an inadequate vehicle procurement program and an underqualified, undermanned maintenance complex.

The vehicle procurement program has suffered from imbalances caused by the Vietnam War, other programs competing for limited funds, and congressional restraints. The manning problem is caused by an inaccurate method of determining manpower requirements. An undermanned shop produces morale and retention difficulties, while the condition of the vehicle fleet deteriorates. A shop may never be manned properly until the methodology of measuring manpower requirements is capable of determining the actual needs of the job.

It has been shown that many factors influence manpower requirements. The division of authority between

base level managers, the program managers at Warner-Robbins AFB, Georgia, policy reviewers at Headquarters, Air Force Logistics Command at Wright-Patterson AFB, Ohio, and Headquarters, United States Air Force at Washington, D.C. tends to diffuse responsibility. There is also a division of authority at several levels between the functional areas of Transportation, Supply, and Maintenance. Even if effective coordination were achieved with all of these USAF logistics activities, there would be difficulties caused by other procurement agencies. Four separate organizations procure USAF vehicles, although the General Services Administration is by far the most important.[7] With different organizational goals and different information systems from the USAF, it is no surprise that maintenance manpower often suffers from many vehicle buys. Specifically, there are too many types, makes, and models, while the specific choices of vehicles are made on the basis of low initial cost rather than lowest overall cost. Since maintenance manpower is a very important component of overall cost, the use of external procurement agencies tends to increase maintenance needs.

The organization most responsible for determining maintenance manpower is Management Engineering.

Currently a management engineering team devoted entirely to transportation units is being established at Dover AFB, Delaware. It will be their task to develop manpower standards and apply them to all transportation activities throughout the world.

The application of standards can be fairly simple if the manning determinant is both accurate and capable of easy calculation. The current determinant, vehicle equivalents, satisfies the latter requirement, but there is doubt about the first. The basis for the current standard was the high correlation between the number of vehicle equivalents and the manpower (as measured by work sampling) needed to maintain the fleet at sample bases. The extremely high correlation of several potential workload determinants, such as vehicles authorized or assigned, suggests that it is the constant value (the B_o in the straight line equation $Y = B_o + B_1 X$) that has the major explanatory effect.

The fault with using vehicle equivalents is that it describes a fleet at a given moment in time. If the distribution, age, mileage, condition, composition, location, or use of the fleet changes, the manpower determination will no longer be accurate.

Existing USAF management reports and regression analysis of the vehicles in Air Force Systems Command and Air Training Command's fleets show that the above factors are clearly important. Particular vehicle makes were not extensively investigated, since most vehicles of a particular management code and year are the same make. Location is thought to be very important, although no device was discovered for including it in a methodology for more accurately determining manpower requirements.

Regression analysis showed that the manpower requirements for the fleet, if not individual vehicle types, could best be estimated by the amount of use generated within the past year. Each vehicle type would have its separate estimating equation. Each base, with a unique collection of vehicle types and usage rates, would then have a tailored manpower level. Since such a system could be computerized and semiautomatic, this system would satisfy the requirement for ease of computation.

The data for the system come from the existing VIMS data base. Since the manhour reporting is for direct labor, an adjustment would be necessary for indirect labor requirements.

The new transportation management engineering team, no doubt, would be able to greatly refine the system

presented here, but even if they should reject this proposal, the finding of a lack of validity of the currently accepted standard requires that it be changed.

While this study has looked extensively at potential problems, solutions have not received as much attention, partly because they are so difficult to implement. If Congress were completely cooperative, and there were no overriding competing uses for funds, the fleet could be modernized. Realistically, the proposed USAF vehicle buy program for 1976-78 is probably the best solution to the problem of an aged fleet. Users should identify vehicle requirements in sufficient detail that GSA or other procurement agencies would buy the correct vehicle, but the procurement agencies must deal with what information is available. The users have little idea of how the unknown features of available vehicles will affect their mission.

The procurement agencies should make buy decisions based on total cost, but there is no way for them to know what the total costs are, especially for new models.

Vehicle requirements should be based on need, but the ability to justify is a more important factor on

buy decisions, and there are few objective means to evaluate vehicle requirements.

There should be no competition for management of vehicles among various functional areas, but realistically, reductions of management positions and prestige are high hurdles for consolidation of vehicle responsibilities.

The list could go on, but the real objective of this study is not only to identify problems, but also to suggest solutions. In doing so, it must be recognized that a value judgment is being made, i.e., a solution to one problem comes at a price in terms of its effect on other problems.

In the area of procurement, it must be reluctantly concluded that the effect of retaining older vehicles beyond their projected life is mostly mission-oriented. Older vehicles appear to require less total maintenance, not because the vehicle is not breaking more often, but because it is being used less often. The new vehicles are being used more intensively. In terms of policy, this suggests that, if budgetary restrictions prevent replacement, older vehicles should be retained beyond their "economic life," rather than just doing without or rationing newer vehicles intensively. This is the current

USAF procedure. It is often criticized, but appears to be a reasonable, valid decision. It does not mean that total cost could not be lowered by increased new procurement, but that it is the best interim decision until the fleet can be upgraded.

Procurement could be improved. There are entirely too many vehicle types and makes. The types could be reduced by a greater screening of requirements. Further, the relatively unique vehicles could be consolidated, as could vehicle makes. By making all sedans at a given base a given series, say 1971-73 AMC, the supply and maintenance costs could be lowered. Similarly, a multi-year buy is desirable. There are definite advantages to large buys of similar fleets. The airline industry is now learning that the advantages of an all-Boeing or all-McDonnel-Douglas fleet outweighs any temporary advantages of good financial deals or slight performance edges that might produce a mixed fleet.

The temporary procurement-management actions should be to consolidate type-models as much as possible. New buys should satisfy multiyear requirements, or should give special emphasis to makes already in the inventory. It has to be recognized that this policy can be criticized

as being "favoritism," since it aids manufacturers already in the system. But if a manufacturer were to change makes or designs extensively, the advantage would be eliminated, and "open" bidding would again be appropriate. Government fleet purchases would not be so important as to discourage innovation, but it would encourage manufacturers to consider commonality. GSA is supposed to consider total cost, and the evidence is clear that large numbers of similar vehicles lower supply and maintenance costs. If necessary, USAF should specify vehicles by make/model (or design specifications so specific that only the desired make/model could qualify) in order to insure that outside procurement agencies only purchase vehicles that provide the commonality with the existing fleet. If the manufacturer raises the purchase price to unreasonable levels, or the vehicles are of unacceptable quality, USAF could always go back to open bidding.

Even consolidating, screening, mass-buying, or modernizing will not make maintenance manning accurate. These actions may reduce maintenance requirements and, perhaps, the total cost of owning the vehicle fleet, but correct manning, with all of the advantages of increased retention, morale, skill, and condition of vehicles, must

await a new methodology of determining manpower requirements. While the present method is plainly inadequate, the variability of vehicle characteristics makes any system susceptible to errors. The high correlation found in the 1967 study between manpower required and vehicle equivalents appears to be caused by a high constant term. The extremely high correlation between nearly all factors related to fleet size, in numbers, and manpower shows that the composition, make, age, condition, use, or location of the fleet had little impact at that time.

Without questioning the accuracy or conclusions of the 1967 study which formed the basis of present manpower authorizations, it can be stated that other factors do influence maintenance manpower today. The location of a vehicle is very important. It can be seen from the considerable variance of manpower requirements by vehicle type from command to command. Unfortunately, the cause for locational differences is difficult to identify. It could be caused by poor roads, difficult terrain, mission, location near salt water, climate, traffic congestion/hazards, availability of an English-speaking workforce, alternative transportation capability, or many other factors. The data are not in the VIMS data base, so it is

being reluctantly ignored. Certain areas, such as Alaska, supposedly do receive additional manning because of location factors. Such is not always the case. In the Pacific area, many bases have local national workers who, through language difficulties or social customs, do not have the same productivity as U.S. technicians.

The Vehicle Integrated Management System data base does provide information on total use, rate of use, age, and measurements of usage compared to expected lifetime. Some vehicles do not have this full data base, since usage is not reported. Fortunately, these vehicles tend to have low and relatively stable maintenance requirements. Other vehicles have a full range of information. Age and total mileage/hours tend to be highly correlated due to vehicle rotation policies. Both of these are affected by a tendency for older/higher mileage/hour vehicles to be less intensively utilized. The single best predictor of maintenance requirements is the degree of recent usage. This is partially understandable since many routine inspection or servicing activities are also tied to the rate of usage.

Despite other influencing factors and the effects of variability on any given vehicle types, the rate

of usage provides a viable means of determining manpower requirements for vehicle fleets. Although the system is not perfect, it is at least better than the present system.

A proposal for change in manpower determination must be more accurate and capable of being updated easily. The following steps would be necessary for such a tailored-to-type system:

1. The VIMS data base must be more accurate. There are presently far too many errors to automatically process the data by computers.
2. Each base or reporting location will have to prepare a report similar to the one used in this study. Since this involves data already in base level data bases, the report involves a minor, one-time programming problem, after which each base could provide the data with little effort.
3. The recipient of the data (USAF?, AFLC?, WRALC/MMC?, MET?) would send each vehicle type through a regression routine. Although OMNITAB II was used in this study, the USAF statistical package contains a compatible system. The manpower requirements for vehicles which have no usage data could be estimated by a simple average. Other

vehicles would be included in data that produces a regression equation. After the estimating equation was made, each base would be analyzed, using the usage data for vehicles at that base. Combined with the average manhours for vehicles with no usage data, a total direct manhours per base would be the result.

4. The direct manhours would have to be modified by the indirect manhours needed for cleanup, supervisions, training, etc. This total would then be converted to manpower, depending on whether military or civilian resources were used.

Under this tailored-to-type system, if new vehicles entered the fleet, manpower requirements would be reduced. If retention and skill levels increased, manpower would automatically be reduced. If complexity of vehicles increased, manpower would automatically be increased.

In short, a semiautomatic, accurate system can be developed that provides the best estimator of manpower requirements, regardless of the condition or composition of the fleet at any base. Further, through simulation, vehicle managers can determine the effects of procurement

and vehicle management actions. This, in turn, can affect disposition and buy positions.

This paper has reviewed a complex situation. It cuts across the responsibilities of many agencies, many levels of command, and many functional disciplines. Perhaps it is because the interface is so multifaceted, while the responsibilities are so diffused, that the vehicle fleet, and particularly maintenance manpower, has had problems that have proved difficult to resolve. Some of the problems may be unsolvable; others may be solved with the cooperation and goodwill of all interested parties.

The analysis presented here is based on available data, and necessary assumptions. More complete information would perhaps alter some of the conclusions. It is hoped, though, that this study will spur serious thought in considering the relationship of the many factors, and the eventual change, of the system to better maintain the vehicle fleet at the lowest cost.

APPENDIX A

EXTRACT OF VEHICLE MANAGEMENT REPORT

APPENDIX A

EXTRACT OF VEHICLE MANAGEMENT REPORT

Management Code	A-J			K-U		
	Inventory Size	Average Manhours per 1000 Miles/ 100 Hours	Average Manhours	Inventory Size	Average Manhours per 1000 Miles/ 100 Hours	Average Manhours
			Vehicle Equivalent--0.1			
K431	---			1	N/A	---
K430	---			38	N/A	4.6
L426	4	N/A	4.5	621	N/A	9.8
C425	---			2	N/A	2.3
			Vehicle Equivalent--0.2			
K450	5	N/A	2.9	592	N/A	3.4
			Vehicle Equivalent--0.3			
D665	---			8	N/A	31.7
			Vehicle Equivalent--0.4			
C340	---			89	28.9	91.7
L486	5	N/A	11.6	262	N/A	9.6
K420	3	N/A	17.6	86	N/A	12.8
C459	2	N/A	5.7	306	N/A	7.6
B401	---			358	N/A	33.2
L461	9	N/A	21.8	10	N/A	36.1
B407	---			227	N/A	19.9
B409	1	N/A	51.5	679	N/A	16.1
K454	---			493	N/A	6.3
L485	9	N/A	0.7	76	N/A	5.8
K409	5	N/A	8.1	193	N/A	17.5
K407	3	N/A	36.2	190	N/A	20.9
K411	2	N/A	1.0	23	N/A	32.4
L438	1	N/A	---	29	N/A	8.6
B448	---			23	N/A	11.1
B420	---			123	N/A	19.4
C439	---			36	N/A	20.1
L437	1	N/A	---	---		
L377	2	N/A	---	---		
K403	---			6	N/A	2.7
C465	---			37	N/A	9.8
K437	2	N/A	8.0	---		
B417	---			59	N/A	23.0
B411	1	N/A	12.0	185	N/A	34.7
L499	1	N/A	----	74	N/A	12.5
L474	7	N/A	4.6	---		
C438	---			67	N/A	10.2
C440	---			12	N/A	29.2
C436	---			6	N/A	---
K452	5	N/A	15.3	223	N/A	4.7

Management Code	A-J Inventory Size	A-J Average Manhours per 1000 Miles/ 100 Hours	A-J Average Manhours	K-U Inventory Size	K-U Average Manhours per 1000 Miles/ 100 Hours	K-U Average Manhours
C490						
B442	1	N/A	2.0	58	N/A	10.0
L467	---			8	N/A	0.6
L460	1	N/A	---	10	N/A	27.1
L470	4	N/A	3.5	5	N/A	4.0
L469	9	N/A	4.9	7	N/A	2.0
B443	2	N/A	10.0	20	N/A	9.1
C437	---			27	N/A	1.7
B447	2	N/A	11.0	26	N/A	19.4
B444	---			7	N/A	11.9
K444	6	N/A	15.1	21	N/A	6.3
B412	---			9	N/A	36.6
E965	1	N/A	3.0	17	N/A	11.6
C455	---			22	N/A	17.1
			Vehicle Equivalent--0.5			
D682	2	N/A	2.8	101	N/A	8.9
D685	---			15	N/A	14.7
D717	38	N/A	10.1	49	N/A	8.5
D719	---			6	N/A	16.2
D718	20	N/A	21.6	38	N/A	14.9
D721	---			11	N/A	15.8
D684	1	N/A	3.0	17	N/A	5.0
D999	---			3	N/A	14.4
D686	---			2	N/A	10.8
			Vehicle Equivalent--0.6			
L397	20	N/A	10.6	13	N/A	14.9
L412	4	N/A	2.6	6	N/A	6.0
C407	---			10	N/A	2.6
B423	2	N/A	3.5	279	N/A	21.7
C419	1	N/A	100.5	3	N/A	56.0
K423	61	N/A	9.5	5	N/A	11.9
L395	5	103.6	25.5	4	7.8	47.7
L405	20	N/A	28.8	11	N/A	32.0
L414	4	N/A	1.8	5	N/A	3.3
L410	2	N/A	4.0	1	N/A	---
L398	16	N/A	9.0	25	N/A	5.5
L399	---			9	N/A	15.9
C393						
C379	---			1	N/A	---
C395	---			32	N/A	33.9
C397	---			20	N/A	6.0
C400	1	N/A	20.8	10	N/A	4.6
C414	---			4	N/A	8.4
D570	13	31.3	112.3	67	33.3	121.4

Management Code	A-J Inventory Size	A-J Average Manhours per 1000 Miles/ 100 Hours	A-J Average Manhours	K-U Inventory Size	K-U Average Manhours per 1000 Miles/ 100 Hours	K-U Average Manhours
			Vehicle Equivalent--1.0			
B101	6	2.8	20.9	20	4.7	24.4
B102	4	20.4	32.1	19	4.6	16.7
B103	6	5.4	8.9	10	4.1	7.8
B104	658	7.2	68.1	1584	5.9	45.1
B152	584	5.9	61.4	1086	5.7	56.2
B105	3	57.3	35.2	27	5.3	15.4
C157	244	8.1	41.7	271	8.3	38.8
B186	13	8.7	84.5	3	10.9	78.9
L160	5	93.7	31.5	11	127.2	119.5
B176	1976	12.7	75.2	2167	7.3	59.2
B274	2	78.1	34.0	1	2.4	1.0
B193	92	5.6	86.3	125	2.6	52.5
B183	6	10.0	113.6	12	18.6	95.5
B177	1	---	---	---		
L260	4	41.1	38.3	1	128.6	27.0
L157	2	36.3	4.5	---		
C163	---			40	7.6	153.7
B399	2	25.9	27.9	12	11.1	9.3
B204	4155	7.3	52.6	5532	5.2	52.4
C260	110	17.4	71.9	222	14.3	63.2
B190	11	13.6	69.8	6	1.7	2.0
B217	1126	8.9	68.7	840	6.6	55.0
B263	1564	10.2	54.2	1712	9.2	46.6
B261	279	8.3	37.9	---		
B185	253	9.1	62.4	526	6.8	61.8
B202	4262	9.2	28.4	---		
C166	1	12.1	30.5	3	22.1	12.7
L433	---			1	N/A	12.0
D750	---			1	1.5	11.5
D606	8	N/A	32.8	217	N/A	47.1
D620	13	N/A	34.2	112	N/A	34.3
D590	---			1	N/A	4.0
D780	7	87.9	93.6	5	48.9	43.1
D703	2	N/A	7.5	12	N/A	14.1
D702	23	N/A	16.7	81	N/A	18.6
D775	---			1	3600.0	36.0
D687	3	N/A	10.8	---		
E927	4	9700.0	24.3	9	1887.5	8.4
E999	---			9	25.3	6.4
E810	4	24.4	17.5	38	16.2	32.8
E811	---			17	12.2	24.8
E801	296	10.4	43.3	1258	9.6	49.8
#906	1	2.1	1.5	1	49.7	16.4
E908	24	1.3	7.5	13	57.9	27.2
			Vehicle Equivalent--1.2			
B222	1009	11.0	57.9	906	8.0	58.9
B205	10	12.5	30.5	---		

Management Code	A-J			K-U		
	Inventory Size	Average Manhours per 1000 Miles/ 100 Hours	Average Manhours	Inventory Size	Average Manhours per 1000 Miles/ 100 Hours	Average Manhours
			Vehicle Equivalent--1.5			
E157	19	9.9	86.5	115	14.2	61.2
E153	28	6.8	56.9	166	5.5	32.9
E164	160	27.8	50.9	258	21.4	34.5
E165	---			17	9.1	50.5
E158	2	5.8	44.3	102	11.1	52.1
K237	119	8.7	49.2	493	13.6	46.6
K199	398	11.0	30.4	546	13.3	39.7
E174	2	7.0	30.3	23	5.8	25.3
E168	15	9.8	22.5	1	6.2	32.6
E169	12	6.8	21.3	1	8.2	29.0
D548	141	11.7	51.5	592	13.8	55.3
D545	16	5.9	23.2	29	7.9	35.0
D660	4	N/A	17.4	41	N/A	10.9
D659	---			4	N/A	7.0
D661	4	N/A	31.6	1	N/A	7.0
D665	---			8	N/A	31.7
D604	5	76.9	15.1	47	20.1	54.8
D605	2	N/A	13.9	92	N/A	17.5
E850	---			1	15.1	88.9
E873	2	2.0	1.1	---		
E890	---			1	39.9	51.5
E893	---			4	21.0	37.1
E833	61	8.9	41.1	10	6.0	55.9
E874	3	18.9	2.8	---		
E957	18	61.1	58.1	99	11.1	47.8
E827	---			1	N/A	7.7
E960	2	33.3	39.9	38	26.9	91.1
E825	---			4	33.1	17.0
D730	1	N/A	166.0	3	N/A	1.8
D722	1	N/A	[illegible]2.6	11	N/A	26.4
E921	3	105.4	16.2	1	385.7	27.0
E922	2	40.7	12.0	1	5200.0	52.0
E920	---			1	N/A	9.5
E842	29	4.3	24.7	149	8.8	25.5
E855	7	13.6	26.5	21	9.9	22.0
E831	214	19.5	83.2	433	18.2	77.4
E954	2	30.4	72.5	41	21.5	28.7
E834	95	10.5	61.8	322	14.8	52.7
E853	1	9.3	75.3	84	12.9	49.4
E832	281	11.8	58.5	666	13.2	63.9
E835	---			2	103.5	82.3
E841	13	7.3	24.1	249	9.9	34.2
E956	18	22.4	92.0	446	19.9	117.2
E952	140	13.7	68.8	21	17.2	68.4
E844	---			10	5.9	62.7
E830	289	7.8	46.5	424	8.2	59.0
E820	10	32.9	148.9	42	28.5	81.6
E967	56	7.2	53.1	99	6.2	48.8
E895	---			36	N/A	18.7
E950	---			154	17.4	104.9

Management Code	A-J Inventory Size	A-J Average Manhours per 1000 Miles/ 100 Hours	A-J Average Manhours	K-U Inventory Size	K-U Average Manhours per 1000 Miles/ 100 Hours	K-U Average Manhour
			Vehicle Equivalent--1.6			
B113	---			21	5.1	27.9
B108	15	10.2	99.9	24	4.5	73.4
B119	470	8.0	106.2	955	10.1	94.9
K161	---			5	16.3	10.6
K164	2	115.9	37.9	50	26.4	38.3
B110	4	38.2	36.0	4	4.5	26.8
B111	---			5	13.6	36.1
C349	---			2	3.1	81.3
			Vehicle Equivalent--1.7			
B199	127	7.0	43.4	62	11.3	56.4
			Vehicle Equivalent--1.8			
D622	11	37.5	160.7	234	24.8	182.2
			Vehicle Equivalent--2.0			
C506	---			2	110.3	304.2
L279	---			67	28.6	65.6
K368	13	41.9	34.0	5	108.1	27.4
D751	1	10.0	3.0	6	553.1	19.1
D767	---			9	N/A	3.5
D787	14	2.1	100.8	5	1.6	106.7
D680	---			17	15.6	25.6
D706	---			2	1050.0	26.3
D676	5	35.9	27.1	126	33.9	63.9
D678	---			15	40.1	43.0
D675	1	249.2	94.7	---		
D705	10	19.6	36.4	7	62.9	25.7
E925	3	46.3	72.8	42	18.1	65.3
E902	1	3.9	12.7	39	8.3	31.3
E900	2	57.7	27.1	---		
E904	1	25.2	22.1	---		
C250	15	56.3	126.0	92	19.5	79.1
L361	11	N/A	49.3	3	N/A	76.8
			Vehicle Equivalent--2.2			
C165	---			2	137.7	192.1
			Vehicle Equivalent--2.4			
L351	214	3.6	84.3	655	4.3	95.9

Management Code	A-J Inventory Size	A-J Average Manhours per 1000 Miles/ 100 Hours	A-J Average Manhours	K-U Inventory Size	K-U Average Manhours per 1000 Miles/ 100 Hours	K-U Average Manhours
			Vehicle Equivalent--2.5			
B139	---			45	14.2	161.1
B134	24	40.5	153.0	8	16.8	143.5
B129	18	16.7	127.0	560	16.2	130.5
C300	138	46.4	113.8	185	53.3	120.2
C207	---			1	7.3	13.5
K333	7	17.2	29.9	3	5.3	8.7
L338	2	224.0	5.6			
K371	19	29.1	54.7	181	26.0	64.9
L107	32	35.5	79.9	36	30.5	83.9
L108	3	86.4	62.5	42	44.9	89.1
C198	48	10.9	34.4	75	13.6	40.2
K251	30	11.7	12.1	622	14.8	21.0
C307	1	5.4	37.4	12	21.7	85.1
B239	9	37.3	34.9	172	16.5	57.4
B352	195	11.7	43.7	236	13.9	42.0
B305	1	---	---	1	---	---
B350	341	20.1	75.3	371	12.2	67.7
C155	---			1	---	---
C322	168	20.4	89.4	380	16.4	85.5
L155	3	1.1	19.7	---		
L201	6	0.6	10.7	3	3000.0	1.0
L202	---			4	16.1	7.6
C310	---			2	57.5	93.0
C243	---			14	173.4	55.1
C263	2	---	---	2	---	---
C265	2	31.7	20.8	11	1.0	3.0
C267	19	49.7	38.7	34	72.1	23.3
D547	149	11.4	38.3	13	16.6	36.9
D541	417	10.9	56.1	1047	9.5	92.9
D560	---			637	8.0	46.3
D999	---			3	N/A	14.4
D624	36	34.4	76.9	163	17.7	135.8
D650	2	150.5	76.4	---		
D707	---			1	---	---
L101	7	394.9	35.5	---		
C197	---			2	10.5	60.0
L349	---			5	38.3	9.0
B232	13	24.3	28.7	35	7.3	31.6
C104	7	57.8	128.8	80	35.0	129.1
B240	89	27.1	50.0	18	9.9	46.1
K250						
B276	5	11.3	40.2	8	8.1	29.4
B360	105	56.1	80.4	325	35.4	41.7
L300	4	9.2	28.4	4	4.3	38.0
C203	---			2	122.6	16.3
B354	1	1.2	21.8	---		
L505	---			22	27.6	172.6

Management Code	A-J Inventory Size	A-J Average Manhours per 1000 Miles/ 100 Hours	A-J Average Manhours	K-U Inventory Size	K-U Average Manhours per 1000 Miles/ 100 Hours	K-U Average Manhours
			Vehicle Equivalent--2.7			
C161	---			62	36.5	146.0
C301	9	45.5	25.6	12	40.0	57.3
C160	4	14.2	21.6	177	45.9	93.1
C199	1	---	---	---		
C200	7	25.3	55.1	104	27.3	40.4
			Vehicle Equivalent--3.0			
C338	---			65	33.3	104.1
L269	---			4	146.4	84.1
L278	---			69	13.3	78.4
L305	---			2	16.6	11.7
L315	---			11	42.4	29.6
B327	---			2	---	---
C205	---			3	22.5	3.3
B325	80	33.8	191.0	63	32.7	228.5
L304	---			16	30.4	82.0
B999	3	N/A	17.5	15	N/A	63.2
B356	---			1	---	---
C240	---			41	25.6	50.1
C241	2	67.1	46.0	42	30.8	69.8
L270	53	90.9	121.9	27	53.8	108.4
B363	3	4.9	98.3	57	26.8	158.6
B377	----			77	11.9	47.3
C242	4	225.6	58.9	73	34.7	59.2
B362	160	29.5	96.9	383	33.8	96.1
C333	42	109.1	153.4	16	56.6	116.0
C331	167	42.7	122.6	335	34.5	128.3
B241	7	32.2	22.4	5	21.9	50.3
B307	8	42.3	32.2	---		
C323	6	16.5	52.6	---		
B233	9	29.1	65.9	74	21.9	48.9
B361	19	36.8	58.1	16	17.8	70.3
L389	2	N/A	45.5	146	N/A	8.9
L500	---			16	15.8	105.8
D754	---			3	14.8	63.5
D762	---			16	53.6	34.8
D769	---			25	66.5	99.3
D763	3	70.5	5.2	11	312.1	59.6
D765	1	---	12.2	11	53.6	4.8
D768	---			13	33.4	24.1
D766	---			9	N/A	3.5
D732	---			18	28.3	45.7
D715	2	N/A	12.5	10	N/A	7.9
D777	---			10	98.7	85.2
D720	5	212.3	66.2	65	28.8	47.1

Management Code	A-J Inventory Size	A-J Average Manhours per 1000 Miles/ 100 Hours	A-J Average Manhours	K-U Inventory Size	K-U Average Manhours per 1000 Miles/ 100 Hours	K-U Average Manhours
D783	---			1	3533.3	53.0
D761	2	N/A	---	2	N/A	0.5
D760	3	N/A	20.3	21	N/A	34.9
E958	---			151	29.2	67.5
E862	1	26.2	41.2	---		
L999	---			1	2.1	0.5
L149	---			127	23.4	81.1
C324	---			1	20.9	74.5
		Vehicle Equivalent--3.5				
B141	21	38.4	89.6	69	67.2	102.2
C170	38	16.2	162.2	85	10.3	112.0
C181	79	4.1	202.3	39	3.1	152.9
C113	---			53	40.7	145.9
C182	1	---	---	2	8.5	158.7
C176	---			2	654.0	244.6
C183	20	13.3	81.2	54	21.3	87.8
C306	1	1.2	72.5	14	21.0	114.8
C211	---			82	14.7	109.9
C120	---			8	50.3	202.5
L376	35	N/A	59.1	68	N/A	44.7
L374	12	N/A	59.3	1	N/A	---
L362	62	N/A	52.6	6	N/A	79.5
L391	16	N/A	6.5	16	N/A	21.8
L390	1	N/A	3.0	22	N/A	15.0
L363	4	N/A	51.1	20	N/A	36.0
L382	---			14	N/A	26.4
L385	---			11	N/A	5.5
D655	82	31.0	144.4	286	17.8	104.9
D669	3	1033.3	20.7	40	39.5	56.6
D668	---			3	37.0	63.3
D656	---			4	13.2	70.8
D731	3	34.1	38.7	287	67.9	113.0
D582	41	49.0	121.4	123	67.2	94.7
D583	19	58.3	78.3	286	51.4	205.9
M731						
L126	82	6.8	98.0	133	7.8	120.3
L418	9	N/A	72.7	55	N/A	79.5
L125	60	5.6	83.4	77	14.1	147.2
L133	2	11.2	112.0	127	5.2	98.2
L130	---			123	15.8	170.8
L124	---			1	66.8	272.0
L139	110	16.0	279.6	90	17.3	426.7
L416	3	N/A	44.1	44	N/A	109.7
L387	---			5	---	5.5

Management Code	A-J Inventory Size	A-J Average Manhours per 1000 Miles/ 100 Hours	A-J Average Manhours	K-U Inventory Size	K-U Average Manhours per 1000 Miles/ 100 Hours	K-U Average Manhours
			Vehicle Equivalent--4.0			
L353	2	15.1	23.9	179	9.7	97.5
C317	---			2	43.2	55.9
D569	3	20.4	195.4	112	16.1	81.5
D572	---			4	28.8	34.0
D568	13	25.3	32.8	179	20.2	107.3
D567	2	64.3	42.8	2	159.2	112.3
D626	1	---	---	9	9.5	18.1
D630	36	6.6	51.3	3	65.7	172.5
D631	70	24.6	112.5	182	30.4	132.9
D640	---			56	22.7	177.3
D633	---			1	56.6	34.5
D535	1	365.4	38.0	9	967.8	51.1
D632	2	68.8	71.9	147	10.6	123.5
D635	1	437.5	17.5	12	117.0	89.7
D641	---			4	38.0	44.7
D645	---			5	18.2	39.9
D536	---			3	43.1	61.0
D537	---			15	2039.0	54.4
D792	---			1	---	---
D790	2	---	---	3	---	20.5
D598	---			2	N/A	41.8
D595	45	5.1	164.4	220	4.0	183.6
D597	---			3	119.5	68.3
D596	---			1	428.6	42.0
D755	1	N/A	1.5	19	N/A	52.8
D701	3	4.6	19.2	29	9.1	38.8
D757	---			2	117.4	22.9
			Vehicle Equivalent--4.2			
C251	32	64.2	153.0	23	32.1	106.9
			Vehicle Equivalent--4.5			
C510	2	252.3	97.0	120	89.8	111.0
C515	13	231.8	144.6	46	93.7	227.0
			Vehicle Equivalent--5.0			
L350	76	10.5	121.2	190	13.0	114.4
L276	49	27.2	112.8	172	21.0	161.1
D580	29	79.3	84.1	167	132.4	116.1
D581	5	702.7	123.4	84	86.3	221.0

Management Code	A-J Inventory Size	A-J Average Manhours per 1000 Miles/ 100 Hours	A-J Average Manhours	K-U Inventory Size	K-U Average Manhours per 1000 Miles/ 100 Hours	K-U Average Manhours
			Vehicle Equivalent--5.5			
D524	---			2	204.2	24.5
D508	20	5.1	61.1	205	14.3	117.7
D520	15	53.0	114.6	7	12.7	91.2
D507	2	3.0	47.5	26	11.1	92.2
D522	6	15.7	22.5	34	30.6	66.7
D526	1	66.7	8.0	8	108.5	41.8
D503	---			5	7.3	58.4
D509	---			3	31.6	388.0
			Vehicle Equivalent--6.0			
D565	5	79.9	27.8	16	19.4	105.4
D540	2	23.7	4.9	1	---	---
D511	---			1	184.8	336.4
D510	1	0.6	18.5	3	33.4	135.4
D528	2	416.8	452.3	8	78.7	115.6
			Vehicle Equivalent--6.5			
L280	---			2	0.2	0.1
L275	---			329	18.1	174.9
C271	---			15	328.1	81.4
L273	2	24.4	138.8	1043	33.2	231.6
L272	158	19.2	147.1	39	11.6	174.6
			Vehicle Equivalent--8.0			
L354	---			41	33.8	103.5
			Vehicle Equivalent--10.0			
L143	13	63.0	500.5	212	38.8	582.7
L141	8	64.7	56.3	---		
L145	---			120	23.1	380.1
L153	---			1	293.8	540.5
L151	1	12.7	31.0	79	11.1	74.1
L137	31	86.8	118.9	15	471.2	188.1
L147	83	13.4	61.0	41	16.3	108.4
L349	---			5	38.3	9.0
E935	139	27.5	107.9	80	19.3	113.8
E938	16	60.1	341.0	60	48.4	291.5
E943	---			1	223.5	185.5
E942	---			4	68.9	590.2
E941	---			6	87.3	21.7
E939	---			31	35.0	314.6
			Vehicle Equivalent--12.0			
E144	---			5	13.7	79.4
E886	---			8	22.6	70.9

A P P E N D I X   B

WORK CENTER RESPONSIBILITIES--

MANAGEMENT

APPENDIX B

WORK CENTER RESPONSIBILITIES--MANAGEMENT

DIRECT:

1. Supervision. Performs necessary supervision involving organizing, planning, directing, coordinating, and controlling the efforts of vehicle maintenance personnel; includes responsibility for the overall supervision of major and minor maintenance on motor vehicles and special equipment such as general purpose, fire fighting, crash and rescue, refueling vehicles, allied equipment, aircraft towing and recovery equipment, base maintenance and material handling equipment. Manages and monitors the Vehicle Maintenance Contract program.

2. Procedures Development and Analysis. Analyzes shop procedures and develops a system to improve shop efficiency. Reviews reports such as Monthly Vehicle Master List, Monthly and Quarterly Maintenance Management Reports, Weekly scheduled Maintenance Reports, Monthly Vehicle Operations Summary, and Daily Delayed Maintenance Report. Analyzes records such as vehicle and equipment work orders, individual vehicle records, and limited technical inspection. Prepares an annual estimate for funds, which includes contract maintenance, parts and depot repair from an analyses of the above reports and records and experiences derived from historical data. Develops shop safety and security procedures and maintenance operating instructions.

3. Monitoring. Monitors quality of maintenance, compliance with directives, policies, and work standards and performs quality inspections by randomly inspecting vehicles prior to release to using agencies.

4. Coordination. Coordinates with using agencies via meetings, telephone, and correspondence on vehicle maintenance. Insures that vehicles are obtained for maintenance and inspections and coordinates on actions involving abuse and misuse of vehicles. Coordinates with base supply on vehicle deadlined for maintenance (VDP) and insured attendance at all meetings.

5. Table of Allowance (T/A) and Facility Requirements. Monitors T/A to insure that adequate tools and shop equipment are on hand. This includes screening, justifying and requisitioning. Monitors facility requirements to include justification for action desired.

6. Training. Determines, requests and arranges for appropriate persons to attend courses for upgrading and proficiency purposes. Evaluates effectiveness of on-the-job training by personal observation of work performance and evaluation of written and oral testing. Reviews training charts to determine status of participation and OJT completion.

SOURCE: U.S. Department of the Air Force, Air Force Manpower Standards, Air Force Regulation 26-3 (Washington, D.C.: 7 May 1973), p. 21.

APPENDIX C

WORK CENTER RESPONSIBILITIES--

MAINTENANCE CONTROL

APPENDIX C

WORK CENTER RESPONSIBILITIES--MAINTENANCE CONTROL

DIRECT:

1. Controls. Schedules and controls vehicles and equipment for intermediate maintenance. Debriefs vehicle operator and makes necessary inspections to determine required work. Prepares work orders for work scheduled into the shops and appropriate documents for work to be accomplished by contract. Initiates the individual record for each vehicle and equipment assigned. Assigns priority to work orders. Reviews the scheduled maintenance report to determine which vehicles require scheduled maintenance. Coordinates with using agencies to establish time vehicles should be delivered to the shop. Receives completed work order from work center, assures accuracy, and dispatches to reports and analysis. Controls movement of vehicle and assemblies to and from the contractor. Maintains a copy of contract maintenance processing document work order in an active contract maintenance file until completion of contract. Performs inspections on all vehicles and equipment repaired by contract maintenance prior to acceptance from the contractor.

2. Record Maintenance. Maintains all maintenance control files. Includes filing completed work orders in individual jackets.

3. Supply. Requisitions required parts and materials from appropriate supply sources and temporarily stores all parts and supplies required for work order completion. Makes distribution of materials or parts as required and researches federal stock numbers as required. Turns in serviceable, repairable, and condemned items. Insured that item identification numbers and descriptions are correct and classification identity is appropriate. Coordinates with proper supply elements to maintain sufficient supply levels. Provides means for temporary storage of requisitioned items. Stores and controls authorized bench stock items.

4. Operates and Maintains Tool Crib. Issues and receives tools (such as tools that are classified as special tools and not normally issued in mechanics tool box) on temporary issue receipt. Maintains tools in a serviceable condition. Insures that precision tools are calibrated.

A P P E N D I X   D

WORK CENTER RESPONSIBILITIES--

MAINTENANCE/REPAIR

APPENDIX D

WORK CENTER RESPONSIBILITIES--MAINTENANCE/REPAIR

DIRECT:

1. Maintenance and Repair. Receives vehicles and equipment, inspects for required repairs, annotates work order, performs technical publication research and obtains parts from supply sources. Maintains and repairs components and subassemblies on all types of vehicles and equipment as prescribed by AF 66-12, Vehicle Maintenance Management. Performs quality control inspections on vehicles and vehicle equipment or components. Performs safety inspections on all vehicles and equipment and cleans maintenance areas during and after job completion. Accomplishes limited technical and acceptance inspections. Performs vehicle chassis dynamometer tests and logs micronic filter differential pressure.

2. Allied Trades. Receives vehicles and equipment, inspects for repairs required, annotates work order, performs technical publication research, obtains parts from supply sources, straightens and repairs damaged automotive body parts, removes and installs body sections and aligns body frame, removes, cuts, grinds and installs automotive body glass and finishes automotive bodies to include welding, painting, machine work and fabrication. Cleans work areas during and after job completion.

3. Nonregistered Equipment. Includes all maintenance and repair or allied trades work associated with nonregistered equipment.

INDIRECT:

4. Shop Equipment Maintenance. Performs maintenance required to maintain shop equipment and tools in a safe and reliable operating condition.

5. In-Shop Maintenance. Performs maintenance on vehicular components and assemblies that have been removed for maintenance and not charged to a particular vehicle. Includes all stock chasing and replenishing stock levels when this time cannot be directly related to a vehicle.

6. Supervision. Supervises assigned personnel to include organizing, planning, directing, coordinating and controlling the work center. Receives work orders, determines required maintenance and assigns work to personnel. Reviews completed work orders and checks work completion, evaluates work performance. Attends required meetings and provides information to maintenance control.

7. Training. Administers and receives training relative to the work center to assure that job proficiency, OJT, safety and security procedures are followed.

8. Housekeeping. Performs tasks such as sweeping, mopping and general policing to maintain a safe work area.

SOURCE: U.S. Department of the Air Force, Air Force Manpower Standards, Air Force Regulation 26-3 (Washington, D.C., 1973), p. 26.

APPENDIX E

PARTICIPATING USAF BASES

APPENDIX E

PARTICIPATING USAF BASES

Data for regression analysis were received from the following United States Air Force Bases:

ATC	AFSC
Keesler	Edwards
Chanute	Patrick
Mather	L. G. Hanscom
Columbus	Eglin
Laughlin	Kirtland
Craig	
Sheppard	
Randolph	
Vance	
Reese	
Williams	
Lowery	

B I B L I O G R A P H Y

Books

Andover, Vernon T., and Walsley, Howard L. *Business Research Methods*. Columbus, Ohio: Grid, 1974.

Croxton, Frederick E., and Cowden, Dudley J. *Practical Business Statistics*. Englewood Cliffs, N.J.: Prentice-Hall, 1960.

Draper, Norman, and Smith, Harry. *Applied Regression Analysis*. New York: John Wiley and Sons, 1966.

Farber, Robert. *Employer's Forecast of Manpower Requirements: A Case Study*. Urbana, Ill.: University of Illinois Press, 1958.

Hogben, David; Peavy, Sally T.; and Varner, Ruth N. *OMNITAB II: Users Reference Manual*. Washington, D.C.: U.S. Department of Commerce, 1971.

National Manpower Council. *A Policy for Skilled Manpower*. New York: Columbia University Press, 1954.

Siegel, Irwin H., ed. *Manpower Tomorrow: Prospect and Priorities*. New York: August M. Kelly, 1967.

Springer, Clifford H.; Herlihy, Robert E.; and Beggs, Robert I. *Advanced Methods and Models*. Homewood, Ill.: Richard D. Irwin, 1965.

Taff, Charles A. *Commercial Motor Transportation*. Homewood, Ill.: Richard D. Irwin, 1961.

Ya-lun Chou. *Statistical Analysis*. New York: Holt, Rinehart and Winston, 1969.

B I B L I O G R A P H Y

Books

Andover, Vernon T., and Balsley, Howard L. Business Research Methods. Columbus, Ohio: Grid, 1974.

Croxton, Frederick E., and Cowden, Dudley J. Practical Business Statistics. Englewood Cliffs, N.J.: Prentice-Hall, 1960.

Draper, Norman, and Smith, Harry. Applied Regression Analysis. New York: John Wiley and Sons, 1966.

Ferber, Robert. Employer's Forecast of Manpower Requirements: A Case Study. Urbana, Ill.: University of Illinois Press, 1958.

Hoban, David; Peavy, Sally T.; and Varner, Ruth M. OMNITAB II: Users Reference Manual. Washington, D.C.: U.S. Department of Commerce,1971.

National Manpower Council. A Policy for Skilled Manpower. New York: Columbia University Press, 1954.

Siegal, Irvin H., ed. Manpower Tomorrow: Prospect and Priorities. New York: August M. Kelly, 1967.

Springer, Clifford H.; Herlihy, Robert E.; and Beggs, Robert I. Advanced Methods and Models. Homewood, Ill.: Richard D. Irwin, 1965.

Taff, Charles A. Commercial Motor Transportation. Homewood, Ill.: Richard D. Irwin, 1961.

Ya-lun Chou. Statistical Analysis. New York: Holt, Rinehart and Winston, 1969.

Public Documents

U.S. Bureau of the Budget, Comptroller General Report to Congress, Examination of Costs and Manpower Involved in Maintenance of Non-Combat Vehicles in the Department of Defense, 1962.

__________. Comptroller General. Report to the Congress of the United States. Excessive Quantities of Heavy Trucks and Buses at Selected Military Installations, July 1964.

__________. __________. Report to the Congress of the United States. Unnecessary Costs Resulting from Non-competitive Procurement of Military 3/4 Ton Trucks, August 1964.

__________. Department of Defense. Armed Services Procurement Regulation, 1974.

__________. __________. Guidelines for Handling Dissident and Protest Activities among Members of the Armed Forces. DOD Directive 1325.6, 12 September 1969.

__________. __________. Management, Acquisition, and Use of Motor Vehicles. DOD Directive 4500-36, 30 July 1974.

__________. __________. Replacement and Repair Guidance, and Life Expectancies for Commercial-Type Vehicles. DOD Instruction 4150.4, 5 April 1963.

__________. __________. "Report on Commercial Vehicle Supply Support." Defense Supply Agency, 1969.

__________. Department of the Air Force, USAF Management Engineering Program. Air Force Regulation 25-1, 7 June 1968.

__________. __________. Air Force Manpower Standards. Air Force Regulation 26-3, 2 February 1973.

__________. __________. Manpower and Organization Management. Air Force Regulation 26-6, 7 May 1973.

__________. __________. Manpower Utilization. Air Force Regulation 26-10, 24 February 1964.

__________. __________. Reporting Requirements. Air Force Regulation 77-11, 1971.

__________. __________. Management Engineering Procedures. Air Force Manual 25-5, 7 June 1968.

__________. __________. Manpower Policies and Procedures. Air Force Manual 26-1, 8 May 1973.

__________. __________. USAF Supply Manual. Air Force Manual 67-1, vol. 4, pt. 1, 10 March 1967.

__________. __________. Joint Procedures for the Management of Administrative Use Motor Vehicles. Air Force Manual 77-1, 1967.

__________. __________. Standard Air Force Statistical Utility System: P104Q/TL. Air Force Manual 171-126, 1974.

__________. __________. Vehicle Integrated Management System. Air Force Manual 177-310, 1974.

__________. __________. Vehicle Maintenance Management. Air Force Manual 77-310, 1 January 1976.

__________. __________. Data Elements and Codes. Air Force Manual 300-4, 1972.

__________. __________. Maximum Repair Allowance for USAF Vehicles. T.O. 36A-1-70. Warner-Robins Air Force Base, Ga.: 1976.

__________. __________. Table of Allowances: Vehicles. T/A 010. Warner-Robbins Air Force Base, Ga.: 1975.

__________. __________. Maximum Repair Allowances, Replacement Codes and Priority Buy for USAF Vehicles. T.O. 00-25-249, 1 November 1975.

__________. __________. Computation of Requirements for Replacement Type Items. AFLCM 57-3. Wright-Patterson Air Force Base, Ohio: 1973.

__________. __________. The Vehicular Equipment Program, December 1963.

__________. General Accounting Office. Report to Congress. Cost Reductions Obtainable by Improving the Management of Maintenance of Commercial Vehicles, 1968.

__________. Naval Civil Engineering Laboratory. "Allocation of Vehicles at Centers." Port Hueneme, Calif.: June 1967.

__________. __________. Transportation Equipment Allowance Formulae for CONUS Naval Air Station. Port Nueneme, Calif.: June 1967.

Stewart AFB ACD Management Engineering Team, "Vehicle Maintenance F.C. 4240 Final Report." Stewart AFB, N.Y.: 6 October 1967.

Unpublished Documents

Brooks, Charles H., and Bulen, Douglas W. "An Indexing System for Identifying USAF General Purpose Commercial Design Vehicles for Replacement on the Basis of Age and Mileage Economic Life Expectancies." Master's thesis, Air Force Institute of Technology; Wright-Paterson AFB, Ohio: 1969.

Coleman, Keneth R. "The Determination of Manpower Requirements in the United States Air Force." MBA Professional Report, The University of Texas at Austin, 1974.

Haralson, Donald H. "Analysis of United States Air Force Authorization Criteria for Pickup Trucks." Master's thesis, Air Force Institute of Technology, 1966.

Hart, Lawrence Patrick. "A Replacement Model for Equipment with a Constant Operating Requirement: A Solution to a Department of Defense Allocation Problem

for Tactical Military Vehicles." Master's thesis, University of Maryland, College Park, Maryland, 1969.

Karsten, Ernest R., and McDaniel, Larry T. "Suggested Methods for Implementation of Life Cycle Costing Techniques in the Procurement of Air Force General Purpose Commercial Vehicles." Master's thesis, Air Force Institute of Technology, Wright-Paterson AFB, Ohio, January 1964.

King, Larry L. "USAF General Purpose Vehicle Buy Program." Professional Study, Air War College, 1976.

McAmis, Virgil G. "An Appraisal of the Air Force Vehicle Management System." Thesis, Air Command and Staff College, Maxwell AFB, Ala., June 1966.

Mullen, Michael J.; Henna, Max E.; and Menk, Burl C. "Management of the Air Force General Purpose Motor Vehicles." Master's thesis, Air Force Institute of Technology, Wright-Patterson AFB, Ohio, September 1962.

Olson, Wayne A. "Cost Effectiveness Parameters for Motor Vehicle Replacement." Thesis, Air Command and Staff College, Maxwell AFB, Ala., June 1968.

Perry, Virginia W.; Dodge, Joseph A.; Fossum, L. Dean; Havens, A. Eugene; and Horner, Marion R. "A Replacement Requirement Methodology for Procurement of Army Equipment." U.S. Army Logistics Management Center, Fort Lee, Va., 11 July 1967.

Porter, Fletcher B. "The USAF Vehicle Procurement Program." Master's thesis, Air Force Institute of Technology, 1964.

Reidy, John A. Major, Headquarters, United States Air Force, Washington, D.C. Interview, 30 September 1975.

Smith, Michael, and Burres, Keith E. "An Analysis of the Need for Specialized Management of the Air Force Special Purpose Vehicle Fleet." Master's thesis, Air Force Institute of Technology, 1973.

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